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INDIAN AGRICULTURAL
RESEARCH INSTITUTE, NEW DELHI

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TRANSACTIONS
AND
PROCEEDINGS
OF THE
ROYAL SOCIETY OF NEW ZEALAND

VOL. 68

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OF THE ROYAL SOCIETY OF NEW ZEALAND

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ROYAL SOCIETY OF NEW ZEALAND.

NOTICE TO MEMBERS.

THE publications of the Royal Society of New Zealand consist of—

1. *Transactions*, a yearly volume of scientific papers read before the local Member-bodies. This volume is of royal-octavo size.
2. *Proceedings*, containing report of the annual meeting of the Council of the Royal Society of New Zealand, list of members, etc. The *Proceedings* are incorporated with the quarterly numbers of *Transactions* supplied to members.
3. *Bulletins*. Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of *Transactions*. The bulletins are of the same size and style as the *Transactions*, but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

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THE attention of authors is particularly directed to the following instructions, the observance of which will greatly aid the work of both Editor and printer.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions*.

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to amend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g.*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible, and the number of figures should be strictly limited.

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Instructions to Authors of Papers.

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12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, etc., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of an article or arranged as footnotes. The former method is preferable in long papers. In the list references must be arranged alphabetically, reference in the text being made by writing after the author's name, as it occurs, the year of publication of the work, adding, if necessary, a page number, and enclosing these in parentheses, thus: "Benham (1915, p. 176)." Example of forms of citation for alphabetical list:

BENHAM, W. B., 1915. Oligochaeta from the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 47, pp. 174-285.

PARK, J., 1910. *The Geology of New Zealand*, Christchurch, Whitecombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, etc.—and initials of authors should be given.

14. In accordance with a resolution of the Council, authors are warned that previous publication of a paper may militate against its acceptance for the *Transactions*.

15. *Reprints.*—In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price. [The present rate is 1s 3d per page for 100 extra copies; thereafter 3d per page for each additional 25 copies.]

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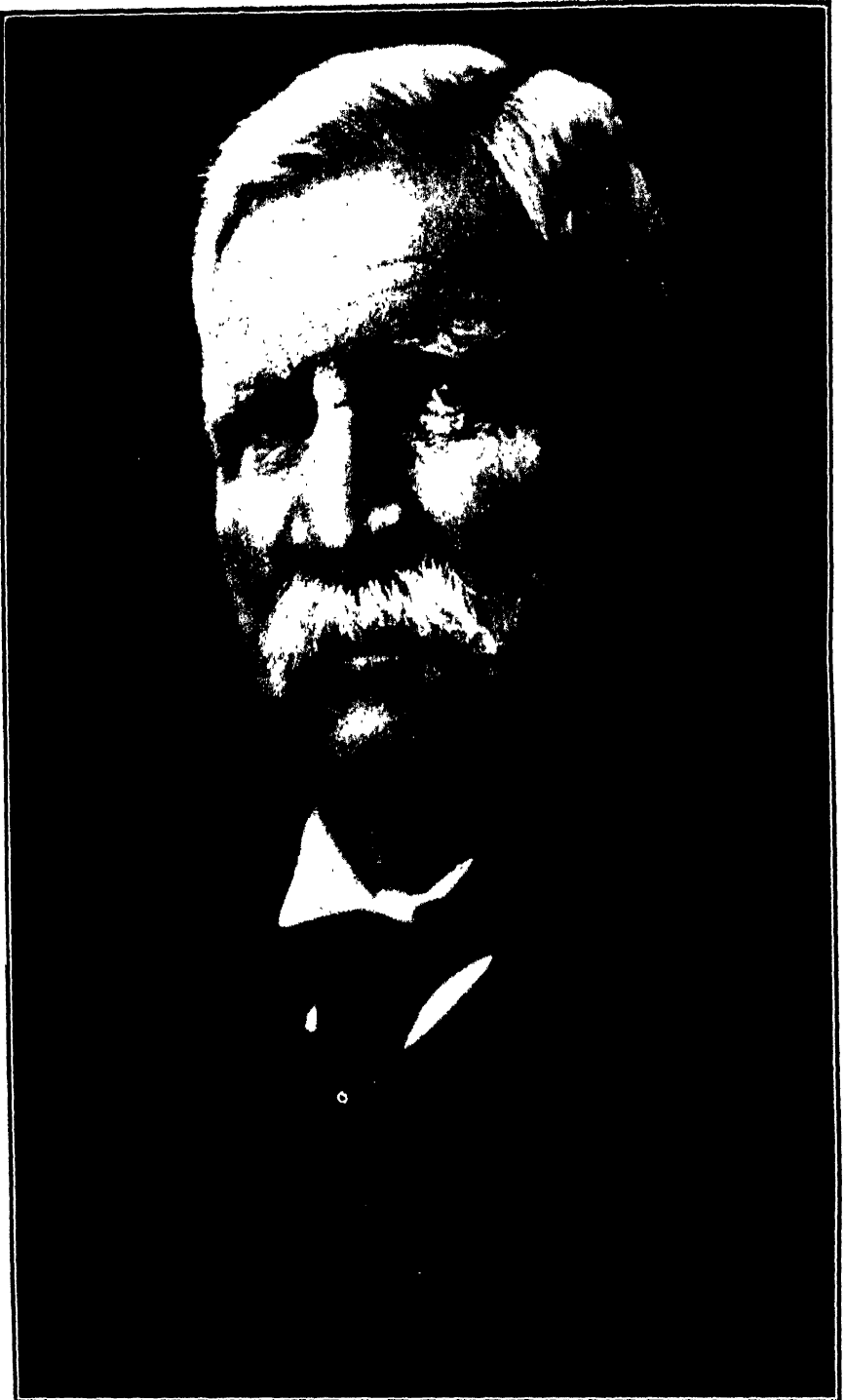
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THE LATE SIR FREDERICK CHAPMAN

Sir Frederick Revans Chapman, 1849-1936.

FREDERICK REVANS CHAPMAN was born at "Homewood," Karori, Wellington, on March 3, 1849, the fifth son of Henry Samuel Chapman, Judge of the Supreme Court, later sometime Colonial Secretary of Van Dieman's Land and Attorney-General of Victoria. He died at Wellington on June 24, 1936. "He was a remarkable man, son of a remarkable father, who, between them, have left in New Zealand judicial circles two records, the one that of father and son both occupying a seat on the judicial bench; the other, that of the father, in occupying a seat in two distinct parts of the Empire." His elder son died in 1917. His younger son, after a distinguished career at Cambridge including full blue for Rugby and half-blue for boxing, joined the Royal Army Medical Corps, and fell in the second battle of Ypres. Sir Frederick is survived by Lady Chapman and three daughters, one of whom, Dr Sylvia Chapman, is the first woman to be elected to a seat on the Senate of the University of New Zealand.

In the course of a survey of his career at Bar and Bench the *New Zealand Law Journal* says:—

"The death of the Hon. Sir Frederick Chapman closes an epoch in the history of the profession of the law in this country. His eighty-seven years of life spanned the whole period of our constitutional government, and his connection with the administration of justice went back to his friendly intimacy in boyhood with our first Chief Justice, Sir William Martin. His father, Mr. Justice H. S. Chapman, was appointed our first puisne Judge when his son was nine months old. Sir Frederick had known all the Judges who have been on the New Zealand Bench with the exception of Mr. Justice Sidney Stephen and Mr. Justice Wakefield. He appeared as junior counsel in a case in which Mr. James Prendergast (afterwards third Chief Justice) appeared on the opposing side. He appeared before all the Judges appointed prior to his own appointment to the Bench, excepting the two already named and Sir William Martin, C.J., and Mr. Justice Buckley, both of whom he knew. And all the Judges appointed since Sir Frederick Chapman's own appointment had appeared as counsel before him when he was on the Bench. . . . In another sense, Sir Frederick's own appointment to the Supreme Court Bench in 1903 was the beginning of a new epoch in the Dominion's legal history. He was the first native-born New Zealander to attain that high office. When he died, our Judges, with one exception, were New Zealand-born."

Those interested in the details of his unique services to New Zealand law will find them recorded elsewhere: here will be noted his services to the natural sciences, particularly to ethnology. In these also Sir Frederick occupies a place which is, in its way, unique. He had been educated in the Melbourne Grammar School, and in France, Germany, and Italy, and he spoke their languages fluently.

More than once he was mistaken by Germans for a German, and when, towards the end of the Great War, he was appointed a Commission to inquire into the treatment of Germans interned on Somes Island, he was able on several occasions to correct the official interpreter. He was for many years a Corresponding Fellow of the Ethnological and Anthropological Society of Italy. He had also a reading knowledge of Spanish and Portuguese.

He was admitted to the Inner Temple in 1871, returning to New Zealand and settling in Dunedin in 1872. On August 13, 1872, he was elected a member of the Otago Institute, retaining membership till 1903, when, on appointment to the Bench, he moved to Wellington. He was a member of the Council of the Institute from 1883 to 1903, inclusive, and was three times president—1887, 1898, 1899. The discussions recorded in the minute books covering the period witness the breadth of his interests and his intellectual keenness. The family connection with the Institute is without parallel, his father, Mr. Justice H. S. Chapman, having been president four times—in the second, third, fourth, and fifth sessions—and the son three times.

He was actively interested in botany, and was the discoverer of several species of *Celmisia* and of the first of the coloured varieties of manuka, *Leptospermum scoparium* var. *Chapmani*. His interest in zoology is indicated by papers on the moas and by his paper, "Considerations Relative to the Age of the Earth's Crust," published in the *Transactions* in 1926. A personal touch may be noted in the fact that though Sir Frederick had lived in Wellington for some twenty-three years, this paper was read before the Otago Institute.

Apart from law, his chief intellectual interests were historical and ethnological, and in the field of European ethnology there was probably no one in Australasia so widely read. He joined the Polynesian Society at its foundation in 1892, and remained a member and an occasional contributor to its *Journal* until his death. His field work in ethnology was confined to collecting on the rich Otago sites, which, up to the present, have probably yielded more material than all the other New Zealand sites put together. The summer holidays spent with his family on these delightful beaches, still unspoiled by weekend shacks, yielded the bulk of the great collection afterwards presented to the Otago Museum. At that time a considerable amount of digging was being done at Murdering Beach and elsewhere, and much of the material found was sold in the open market. Chapman was the reverse of boastful, but he boasted proudly on two points, namely, that nothing in his collection was purchased and that he had collected the rough unpolished tools and pieces that all other collectors had thrown away. He thus became the first investigator in Polynesia of these interesting and important implements. An excursion into archaeology was made in conjunction with Hamilton on the Shag River site in 1890. Plans and records, kept by Hamilton, were never published, but Chapman carefully preserved the three adzes found by him below beds of interlaced moa bones. These were characteristically Polynesian, confirming Alexander Macky's discovery in 1872 of an adze of Polynesian type at the bottom of the moa-hunter deposits at Moa-bone Point, and forecasting the results:

of Teviotdale's exhaustive work thirty years later. Chapman had no leaning towards publication or he would have anticipated a number of students of later years in papers on the wood-working tools of the Maoris. The only paper published by him was a classic, "The Maori Working of Greenstone." As originally submitted to the editor of the *Transactions* it was fully illustrated, but the editor ruthlessly cut the illustrations down to a single one. In spite of mutilation the paper remained in a class of its own in the field of Maori material culture until the appearance, twenty-five years later, of Downes' work on eel-fishing on the Wanganui River and Buck's earlier papers.

The committee of the Otago Museum, to which he gave his ethnographic collection, commemorated his benefaction by naming the gallery which houses the Maori collections the Chapman Gallery. Though he had long lived in Wellington, it was he who was invited to open the Fels Wing of the Otago Museum on its completion in 1929. He presented to the Hocken Library, Dunedin, his great collection of New Zealand pamphlets, a collection which he believed to be complete. Other material and collections were presented to the Dominion Museum and the Turnbull Library. His gift to the Otago Museum was extensive. The large Maori section included unique specimens like the wooden bone-box in the form of a man-headed bird from Centre Island and the painted feather-box from an interment in Southland. There were also notable pieces from Polynesia and Melanesia, and pieces illustrating the Neolithic of Scandinavia and Italy, and the early Pre-dynastic of Egypt.

Chapman's unerring judgment on all matters connected with Maori implements in stone and bone resulted in his being consulted again and again by all who could visit him. To such, his advice was freely given with the clarity which characterised his legal judgments. In this way and through his great gifts to museums and libraries, his influence passed far beyond his published work, making him, in his time, a central figure in New Zealand ethnology.

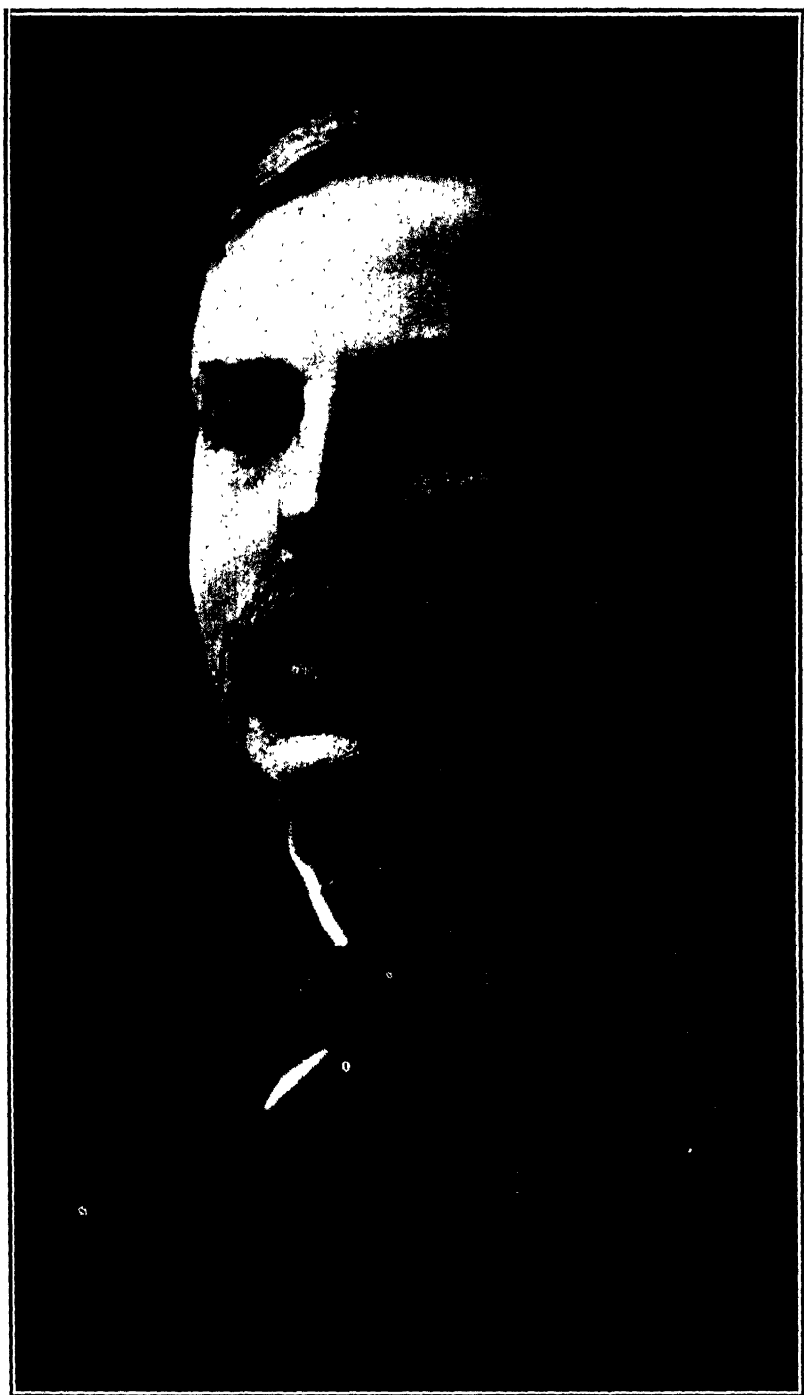
H. D. S.

Baron Rutherford of Nelson, 1871-1937.

THE news of the death of Lord Rutherford on October 19, 1937, which came with unexpected and tragic suddenness, has caused a deep sense of sorrow and personal loss to all who knew him or who had become accustomed to rely for inspiration on his succession of announcements of major discoveries and generalisations. The magnitude of the loss was, on succeeding days, further brought home by the circumstances of his burial in Westminster Abbey and by the flood of spontaneous tributes from world leaders, which have demonstrated not only his greatness as a scientist, but the warm personal regard and esteem in which he was held universally, and the greatness and inspiration of his life as a man.

The terms customarily used in obituary notices somehow seem inadequate to the occasion; yet fortunately a memorial to his greatness already exists in his scientific writings over the past forty years, and is recorded in a manner which lesser men can neither add to nor detract from. Apart from the personal satisfactions of accomplishment arising from his own eager and unquenchable thirst for research and its results, he did not spare himself the onerous task of interpreting these results to his fellows. Each of his publications to this end bears the indelible imprint of the master, clear-cut in reasoning, leading to direct and brilliant experiment followed by a synthesis of the newly-discovered and other relevant facts, freely acknowledged when they were the work of others, to bring out a bold convincing generalisation which leaves the subject completely and comprehensively covered. Looking back over all his numerous published papers, one can find few errors which have crept into the writings and few if any conclusions which he needed to modify later. As a famous professor once said: "When Rutherford says a thing is so, there is no need to check it." One is only left with the wonder that it should be possible for one man in a single lifetime to have accomplished so much. In fertility of mind and constructive imagination, he equalled Newton; in experimental methods and genius, Faraday; but in addition, he had an unparalleled exuberant enthusiasm for his work and a human capacity for attracting and inspiring others to work alongside him in enthusiastic co-operation and good comradeship for which the writer can bring to mind no other leader to compare.

In general, whether a man be a statesman, a philosopher, or a scientist, the position he may ultimately occupy in the view of historians or in international regard is not one which can be estimated even approximately in his lifetime. In the case of Lord Rutherford, however, his pioneering work involved such a great unfolding of Nature's truth and such a revolution in scientific thought, and ushered in an epoch of such rapid advance both in theory and application, that there is already enough perspective to appreciate his genius and work and to realise the honour done to New Zealand by its association with his birth and training. His life and work constitute one of those lights which illuminate the way down the



THE LATE LORD RUTHERFORD,

ages towards an increased understanding of nature and which appear to emerge in the whole world only once in more than a century.

In this article, the hope and purpose is to review briefly some aspects of Rutherford's life and work, more in an endeavour to obtain inspiration and teachings for our own generation than to attempt to give his life in complete detail; much of the latter cannot for obvious reasons be written yet.

The influence of heredity and early environment in the development of genius is an interesting but still incompletely understood subject. Everyone knows that it is from their parents that children derive their bodily and mental qualities; nevertheless, parental influence is not confined to the hereditary constitution of the genes transmitted to the children, but, owing to the long association of children with their parents during the impressionable years, many acquired characteristics and habits of the parents are unconsciously handed on to the children. It is often these acquired characteristics and habits which have a profound influence on a child's career. Looking at Rutherford's origin and upbringing from this point of view we find that, while favoured with a distinctly more than average physical and mental endowment, he was even more fortunate in the qualities which he acquired from his parents and from the country environment in which he was raised. The first twenty-four years of his life, prior to leaving New Zealand, gave him an ideal equipment of physical development, health, training in all its aspects, habits of work and character which fitted him to profit to the full from the larger opportunities of university life at Cambridge to which he was so fortunate as to be called. It was these earlier influences which were of profound importance in assisting him to attain to the unique position in world science to which he rose.

Rutherford inherited high qualities from both his parents, from his father a balanced yet fertile and inventive mind and a rich physical endowment; from his mother, a very high mental equipment. In the habits and qualities he acquired from their example he was however probably even more fortunate.

Lord Rutherford's parents both arrived in New Zealand as young children nearly 100 years ago, in the very early days of the colony. His father, James Rutherford, arrived in Nelson from Scotland in April, 1842, at the age of three, while his mother, Martha Thompson, came to New Plymouth in the early fifties with her widowed mother. They were married in April, 1866, and they had in fairly rapid succession twelve children, of whom Ernest, afterwards Lord Rutherford, was the fourth. He was born at Spring Grove, between Nelson and Motueka, on August 30, 1871. The whole family possessed high mental capacity and good physique. Moreover, under the influence of their parents, they were a singularly united, happy and religious family.

Rutherford's father was a man of great character, of fine quiet disposition, straight and honourable. He was a good, ingenious and resourceful engineer. A characteristic of the father, as later of the son, may be expressed in the words of the poet: "He doeth little

kindnesses—which most leave undone or despise.” His mother was a truly remarkable woman of high education and character, very musical, a good organiser, thrifty, and hard-working. She had a true appreciation of the value of education and had a practical ambition for her children, for in common with most of the early pioneers, the parents even in adversity denied themselves to give their family a good education.

At the age of 15, Ernest Rutherford, after attending the primary schools at Foxhill and Havelock, won a Marlborough Education Board Scholarship (value £52 10s per annum for two years), obtaining the astonishing total of 580 marks out of 600. Thus he went to Nelson College in 1894, and such was his grounding that he was immediately placed in the Fifth Form and soon justified his classification. His first headmaster was W. J. Ford, a famous English cricketer, followed by J. W. Joynt, but it was from a master, W. S. Littlejohn, that he probably gained most inspiration and particularly a grounding in mathematics. He would take long walks over the hills with Littlejohn on Saturdays, and it is said that frequently they would pause to draw diagrams on the ground with a stick to illustrate these discussions. Although Joynt has recorded that Rutherford “displayed some capacity for mathematics and physics but not to an abnormal degree and that he was a keen footballer and a popular boy,” yet he won all the scholarships and prizes available in classics, French, English and mathematics and was Dux of the College. A special characteristic was his ability to concentrate on work or play alike, as the occasion demanded. In his term report in December, 1888, when in the Sixth Form, Ford states: “He is top in every class and his conduct is irreproachable.” Joynt wrote in a later report, “One from whom one may look for good results in the future,” while Littlejohn wrote “Nunquam non paratus. Should give a good account of himself.” He won a Junior University Scholarship in 1889, coming third on the list, which was headed by Marris (afterwards Sir Charles Marris), who was later to be his friend and rival at Canterbury College, which both entered the following February.

At Canterbury he came mainly under the influence of a good Professor of Mathematics, C. H. H. Cook, and an original but somewhat unorthodox Professor of Physics and Chemistry, A. W. Bickerton. More fortunate still, there were several brilliant fellow students and the numbers were of such size that more of a tutorial system was possible. He earned a B.A. in 1892 with senior scholarship in Mathematics; M.A. in 1893 with First Class Honours in both Physics and Mathematics (then a very rare event), and B.Sc., in 1894. During this latter year he taught at the Christchurch Boys’ High School as a part-time and indifferently successful teacher and also carried out researches on a magnetic detector of Hertzian waves, an account of which appears in *The Transactions of the N.Z. Institute* for 1894 (pp. 481–513) in a paper read before the Philosophical Institute of Canterbury, November 29, 1894. These researches were carried out on his own initiative under difficult conditions in a rough basement cellar. As source of electricity he used a battery of Grove

cells, the box for which he constructed in his father's buggy-shed at Pongarehu while on holiday. The cells required attention each morning before he commenced work. Nevertheless, with these slender resources, he produced a very highly sensitive detector, which later held the record for distance of reception. The research was fertile in that it led to many other magnetic detectors of wireless waves and to a large number of patents, including one taken out by Marconi in 1902. Rutherford's interest in the work, however, was purely scientific. In the meantime, he spent each of his long vacations at Pongarehu, where he earned pin money by assisting on the farm or the flax operations. He painted the house, helped in the paddocking of the flax, constructed a tennis court, took long tramps in the hills shooting pheasants, and shared with his eldest brother George in supplementing the education of his sisters.

In 1894 Rutherford was a candidate for the 1851 Exhibition Science scholarship originally founded at the suggestion of the Prince Consort. There must always be difficulty in the award of this scholarship when there are good candidates offering in different subjects, and in this case the award was first made to J. C. Maclaurin, who afterwards filled so worthily the position of New Zealand Dominion Analyst. For family reasons Maclaurin was unable to take up the scholarship, which was accordingly awarded to Rutherford, who left for the University of Cambridge in 1895. He wisely entered Trinity College and the Cavendish laboratory to work under Professor J. J. Thomson, then at the height of his powers. In the interval of uncertainty regarding the scholarship Rutherford had accepted a teaching post at New Plymouth High School, although definitely with the idea of saving up enough money to finance a course at a British university. He entered Cambridge University as one of the first students to be admitted under a new regulation admitting as research students graduates from other universities.

Rutherford started work at the Cavendish Laboratory in October, 1895, and he at first devoted himself to improvements of his radio detector; but he had not worked there more than a few weeks before he had convinced his professor that he was a student of exceptional ability and energy, and the story went round that there was a "young rabbit from New Zealand who burrows very deep." However, a remarkable combination of circumstances caused him to change his line of work. J. J. Thomson and his fellow workers had for ten years been engaged on the problems associated with the passage of electricity through gases in a partially evacuated chamber. These experiments had indicated that electricity was transferred through such gases mainly by particles termed electrons, generated within the chamber, and which appeared to be of the order of $1/1800$ part by weight of the atom of hydrogen. In November, 1895, i.e., a month after Rutherford had gone up to Cambridge, Röntgen had made the astounding observation that when electricity was passed at high voltage through such a chamber with a high degree of vacuum, invisible rays were given off which had the power of passing through the glass walls of the vessel and also through outside opaque objects and of affecting a photographic plate. These rays, called Röntgen-

rays or X-rays, were soon found by J. J. Thomson and others in France and Italy to have other interesting properties in that they made the outside air electrically conducting. Rutherford's attention was attracted to this astonishing phenomenon and he commenced work on it with Thomson, who describes the work as follows:—"Rutherford devised very ingenious methods for measuring various fundamental quantities connected with this subject, and obtained very valuable results which helped to make the subject 'metrical,' whereas before it had been only descriptive."

J. J. Thomson and Rutherford published their results in November, 1896, in a paper entitled "On the Passage of Electricity through Gases exposed to Röntgen-rays." This paper is the foundation of the ionisation theory of conduction of electricity through gases. Interestingly enough there is no reference to the word "ions" or "ionisation" in the whole paper, although gradually there is developed in the paper from the experimental results described, the whole idea of "charged particles" produced by the radiation, their movement under an electric force, their properties of diffusion, recombination and mobility, and the idea of a saturation current as opposed to the ordinary conception of an electric current obeying Ohm's law. This and two succeeding papers on the same subject by Rutherford himself naturally attracted wide attention among physicists; the ideas were at the time so novel that Rutherford in this short interval came into the limelight. Moreover, Becquerel had in the meantime (1896) discovered that uranium and its salts also emitted radiations which like Röntgen-rays were capable of affecting a photographic plate and discharging charged bodies in the neighbourhood. This was the start of the subject of radioactivity, this name being coined by Mme. Curie, who with her husband used this property to isolate radium and polonium from a uranium ore, pitchblende, in 1898.

After the announcement of the radioactivity of uranium, however, Rutherford applied the knowledge and technique of his work on Röntgen-rays to the investigation of the radiation from uranium and thorium, and in 1898 he had completed a masterly analysis giving incidentally a complete verification of the ionisation theory that had originated from his previous experiments on Röntgen-rays with J. J. Thomson. The most important result, however, was that the radiation from uranium was found to consist of an easily absorbed portion which he termed α -rays and a more penetrating fraction which he termed β -rays. The existence of the still more penetrating γ -rays was discovered later. It was these α -rays (or doubly charged atoms of helium as he afterwards showed them to be) which seemed to have a special appeal to Rutherford during the rest of his life and later proved so effective as a tool in unravelling so many atomic secrets.

It is small wonder therefore that when Cox came over from Montreal in 1898 in search for a successor to H. L. Callendar for what was virtually a purely research professorship at McGill University, his inquiries inevitably led him to Rutherford, who ultimately accepted the position. The salary was not large, £500

per annum, but Rutherford stated at the time that the chief attraction was the research facilities available through the munificence of Sir William Macdonald. It is worthy of noting that Sir William Macdonald continued to provide Rutherford with that special apparatus and material, e.g., liquid-air machine, radium, etc., without which much of the glorious story of his achievements would have been impossible.

The year following his appointment he visited New Zealand to marry Mary Newton, to whom he had been faithful since early in his Canterbury College days. She was a very capable, practical woman with a high sense of duty, a keen suffragette and a temperance advocate. She made him a good wife, her house was well run and was always open to his colleagues, research students and visitors from overseas. In the early days of their marriage, particularly, she typed his papers, edited them, helpfully criticised from the layman's point of view his various addresses and particularly his first books on radioactivity. They had only one child, Eileen, a vivacious personality, born the year following their marriage. Her death in 1930 was to Lord Rutherford a very severe loss. She was married to Professor R. Fowler, F.R.S., and four bright children have survived her.

To return to Rutherford at McGill: although at first without the association of those with direct knowledge of his subject, apart from the helpful correspondence of Sir J. J. Thomson and Sir Robert Ball, he quickly settled down to work and attracted to himself many co-workers both from Canada and overseas, for he was far from being a recluse. He "radiated" enthusiasm, interest and will to co-operate. His first experiments related to the nature of the radioactivity of thorium. He noticed that the conductivity of the air, produced by some compounds of thorium and particularly the oxide, varied in a most erratic manner. This phenomenon was traced to some gaseous substance given off from thoria, which could be carried away in a gas stream. He gave the name *emanation* to this unknown substance. He also noticed that all substances remaining in contact with the emanation themselves became radioactive. This excited radioactivity decayed with time, falling to half-value in eleven hours, whereas the emanation itself decayed to half-value in one minute. Thus was born the idea of successive radioactive transformations, and in association with Soddy, who undertook the chemical work, he proceeded to investigate the nature of the various known radioactive substances. Together they discovered thorium X, etc., showed that each radioactive body in the series had different chemical and physical characteristics, and that the gaseous emanation could be liquified and had all the properties of an inert gas of high atomic weight. The great contrast in the physical and chemical properties of these elements, and the exact measurements they carried out, led to their enunciation in 1902 of the bold and startling theory known as the Disintegration Theory of Radioactivity, which embodied the idea of successive radioactive transformations. According to this theory atoms were no longer regarded as permanent, everlasting, and indivisible. Radioactive elements disintegrated spontaneously. They

broke up according to the laws of chance independently of age or their physical or chemical state or surroundings. The mortality rate was constant for any one radioactive substance, but varied widely from one type of atom to another. In each case the disintegration took place with liberation of a large amount of energy which showed itself either by the ejection of an α -particle or a β -particle. Rutherford showed the α -particles to be positively charged and the β -particles negative. From his measurements he deduced that the former were probably atoms of helium, and the latter electrons in swift motion. He also showed that the energy of the α -particles accounted for the spontaneous production of considerable heat by radium. It is perhaps difficult for us to now appreciate fully the revolution in ideas involved in his results and conclusions; even Kelvin was hard to convince.

Rutherford was elected to the Royal Society in 1903 and delivered the Bakerian Lecture in 1904, when he outlined the whole science of radioactivity in a masterly comprehensive study. He travelled to many American universities to give lectures on his subject and received numerous offers of important posts which would have been to considerable financial advantage. He valued facilities and equipment much more highly than money, however, and he was not desirous of changing his nationality, feeling confident that sooner or later a suitable British post would be available to him. This eventuated in 1907 when that brilliant physicist Professor Schuster wrote offering to retire from the Chair at Manchester if Rutherford would take the post.

The subsequent rapid developments are perhaps best illustrated from Rutherford's own words at the presentation to him of the Franklin medal in 1924:—

"In 1907 I left McGill to take the post of Professor of Physics in the University of Manchester, vacated by Professor Schuster. Before leaving Montreal, I had been much interested in the discovery made independently by the late Sir William Crookes and Professor Giesel that the α -rays produced scintillations in phosphorescent zinc sulphide. There was no reason at that time to believe that each α -particle produced a scintillation, but the discovery directed my attention to the importance of finding a method of detecting a single α -particle and of counting the number emitted per second by one gram of radium. Preliminary calculations showed that the ionization current in a gas due to a single α -particle might produce sufficient effect to be detected by a very sensitive electrometer. Doctor Geiger and I attacked this problem experimentally but without much success. It then occurred to me that the electrical effect might be greatly increased by utilizing the property of ionization by collision in a strong electric field. After some disappointments, this method proved successful and we had the satisfaction of showing that individual α -particles could be easily counted by this electric method. This allowed us to determine the number emitted per second by one gram of radium, and, by measuring the positive charge carried by the α -rays, we were able to obtain a fairly accurate value of the fundamental unit of charge, viz. 4.65×10^{-20} , while later precision methods gave 4.80×10^{-20} electrostatic units.

"At this stage, the evidence as a whole strongly supported the view that the α -particle was a doubly charged atom of helium, but it was of great importance to settle this question definitely by a straightforward method. For this it was necessary to collect the α -particles and to show that they gave rise to helium, quite independently of the radioactive matter from which they were expelled. This might be done if a glass tube could be constructed sufficiently strong to contain a large quantity of radium emanation but so thin that the α -particles could be fired through it. I put the problem of the construction of such a tube to Mr. Baumbach, a skilful glass-blower attached to the

University. After a few hours' trial, he produced the first α -ray tube of glass. With this I was able to prove definitely that the α -particles which had been fired from this tube into the walls on an evacuated glass receiver, after diffusing out, gave the complete spectrum of helium.

"Unless I am to take too much of your time, I must confine myself to only a few more points of special interest. I have always, since the discovery of the nature of the α -rays, had a great interest in this type of radiation, and I will now show the steps by which the α -rays were utilized to probe the inner structure of the atom and to throw light on its constitution. In our experiments on counting α -rays by the electric method, we had been troubled by the scatterings of α -rays in passing through matter. Doctor Geiger made a special examination of the average scattering for small angles of reflection. I suggested to one of my Manchester students, E. Marsden, that it would be of interest to examine whether any α -particles were scattered in the backward direction from a metal plate. I did not have any reason to expect a positive result, and Doctor Geiger and I were very surprised when a considerable number of α -particles were found to be scattered through an angle of more than 90 degrees. From Geiger's experiments on the average angle of scattering by metal foils and from the laws of multiple scattering, we could not expect a detectable number of particles to appear in the backward direction. Both Geiger and I appreciated at the time that this was a very strange and remarkable result, difficult to reconcile with existing views of atomic structure. After a number of calculations, I came to the conclusion that this large angle scattering could only be explained if there were intense electric fields in the atom, due to one or more massive charged centres, and that the large deflections were produced by a single collision with such a centre. From this arose the conception of the nuclear constitution of the atom, an account of which was first given by me in 1911. The theoretical laws of scattering on this assumption were very completely verified by the careful measurements of Geiger and Marsden, published in 1913."

The foregoing takes us to the third great epoch-making advance associated with Rutherford. The first was the Ionisation Theory of conduction of electricity through gases, the second the Disintegration Theory and the third the Nuclear Theory of Atoms. In this latter theory the atom is pictured by Rutherford as a miniature solar system, beautiful in its simplicity. The nucleus or central sun had an aggregate of positive electricity, while the corresponding number of (negative) electrons occupied closed orbits round the nucleus similar in some respects to those of the planets round the sun. The charge on the central nucleus and the number of "planets" determined the kind of chemical atom involved.

At this time Rutherford had among other brilliant co-workers in Manchester, Moseley and Niels Bohr, whose work each in his own field verified and extended Rutherford's conception of the nuclear atom. If the nuclear constitution of the atom was correctly conceived, neither the stability nor the modes of vibration of the electron, for example in hydrogen, were explicable on the ordinary classical theory. A radical departure from accepted views seemed essential. This departure, made by Bohr, consisted in a novel application of the ideas underlying Planck's Quantum Theory of Radiation. Bohr's theory applied to the Rutherford atom was triumphant from the first; he not only deduced the nature of the spectrum of hydrogen, but explained the existence of the Pickering and Fowler spectral series and showed that instead of being part of the hydrogen spectrum they were almost certainly due to ionised helium, a prediction which was verified. Moseley, on the other hand, by measuring the X-ray spectra of the elements was able to show that the nuclear charge

of an element was in numerical units given by its ordinal number and that the properties of an element in the periodic table were practically solely dependent on a whole number representing the nuclear charge: one for hydrogen, two for helium, three for lithium, and so on up to 92 for uranium. These theories simplified the whole conception of the relation of chemical and physical properties of successive elements and led to the extraordinary conception of isotopes, i.e. elements with the same nuclear charge and same chemical and physical properties, but with different atomic weights. The atomic weight was shown to be of minor significance compared with the nuclear charge or atomic number.

We must now pass on to Rutherford's next great deduction and discovery. In a collision between an α -particle of mass 4 and the nucleus of an atom, the ordinary laws of conservation of momentum might be expected to apply; and thus if the nucleus of an atom of hydrogen of mass 1 were encountered in direct hit by the α -particle, the former might be expected to be set in motion with a speed much in excess of the incident heavier particle. Thus the present writer established the occurrence of the swift-moving hydrogen nuclei afterwards named protons. It was found, however, that protons were produced when α -particles were fired into ordinary air. Much time was spent in making sure that the effect was not due to adventitious hydrogen associated with the source of α -particles, and Rutherford, repeating the observations during the war period, noted that many more protons were observed in dry air or nitrogen than in dry oxygen. This led Rutherford to the discovery that the protons were generated in nitrogen, the nuclei of whose atoms were disintegrated artificially by close impact with a high-speed α -particle, with the eventual production of an atom of oxygen and a hydrogen nucleus. In subsequent work at Cambridge, Rutherford and Chadwick were able to show that not only nitrogen but also boron, fluorine, sodium, aluminium and phosphorus are disintegrated by α -ray bombardment with the emission of hydrogen nuclei. Thus was accomplished the artificial disintegration and transmutation of elements, the dream of the alchemists of old.

Here it may be mentioned that immediately after the war Sir J. J. Thomson retired from the head of that most famous laboratory, the Cavendish Laboratory at Cambridge, and Rutherford was selected to succeed him. The Cavendish Laboratory was built in 1874 in honour of the Cambridge scientist Henry Cavendish. Its chief founder and first director was James Clerk Maxwell, whose mathematical theory linking up electricity, magnetism and light paved the way for the discovery of radio telegraphy and telephony. Maxwell died in 1879 and was succeeded by Lord Rayleigh, who resigned in 1884 in favour of Professor J. J. Thomson. Thus each of the four succeeding directors of the Cavendish Laboratory has been internationally famous, Rutherford not the least.

To return to our review of atomic transformations: as time went on and the mechanism of these transformations was more understood, new types of radiation were discovered, e.g. the neutron in 1932 by Chadwick (already prophesied by Rutherford). As a result

a very large number of artificially produced radioactive bodies have been isolated not only by bombarding elements with α -particles, but also by bombarding with fast protons, neutrons and deuterons. The next advance was to devise electrical methods of speeding up ions to such a velocity that they could be used for the purpose of producing artificial disintegration of other elements, i.e., the use of streams of particles produced and controlled at will in the laboratory. The pioneer experiments in this field were carried out in Rutherford's laboratory at Cambridge by Cockcroft and Walton, but great developments followed elsewhere, particularly in U.S.A. Costly apparatus on an engineering scale is involved, together with large specially constructed buildings. The availability to Rutherford and his assistants of such facilities was arranged just prior to his unfortunate death, thanks to the magnificent gift of £250,000 by Sir Herbert Austin. In his letter to Earl Baldwin, Chancellor of the University, transmitting the offer, the donor stated:—

“I have for several years been watching the very valuable work done by Lord Rutherford and his colleagues at Cambridge in the realm of scientific research, and knowing that as Chancellor you are keenly interested in obtaining sufficient funds to build, equip and endow a much-needed addition to the present resources. I shall be very pleased indeed to present securities to the value of approximately £250,000 for this purpose.”

The comments of Austin and Rutherford in the *Morning Post* are perhaps more significant. Austin stated:—

“By contrast with American scientific institutions those in this country have been poorly provided with the material means to prosecute research; in particular I know that the Cavendish Laboratory has been handicapped in some of its work by lack of the equipment available at various American centres. The fact that it has none the less held its position is the finest possible tribute to the men who work there.”

Rutherford said with characteristic modesty:—

“I am very gratified at the very generous gift of Sir Herbert Austin and the recognition of the important work that has been done in the past by Sir J. J. Thomson and his colleagues at the Cavendish Laboratory. The first use of the money will be to build a laboratory for the utilisation of very high voltages in order to carry out experiments on the transmutation of matter by high speed particles and by radiation.”

Thus, although his life was not incomplete either as an entity or an achievement, yet as Sir J. J. Thomson said: “His death, just on the eve of his having in the new High Tension Laboratory means of research far more powerful than those with which he had already obtained results of profound significance is, I think, one of the greatest tragedies in the history of science.” Others are bearing and will carry the torch; the world will reap the benefits. The personal influence of Rutherford and the direct impetus of his work will long continue to be felt. The example of his life and work will be the inspiration for generations yet unborn.

Rutherford seldom, in his public utterances, strayed from the scientific subjects in which he was particularly qualified and interested, though he would discuss world and economic affairs with his intimate friends, bringing to the discussion a shrewdness and breadth of vision which showed him to be an unbiassed and keen observer of world movements. In this latter connection, however, it is interesting to quote from the Norman Lockyer lecture delivered only a year before his death:—

“In the present state of industry, when progress and change are rapid, it seems to me that it would be an advantage to the State to know the probable changes to be expected in industry before they were actually put into operation. For this reason, it would seem to me desirable for the Government to set up what I may call a ‘Prevision Committee’ of an advisory nature. The function of this committee would be to form an estimate of the trend of industry as a whole and the probable effects on our main industries of new ideas and inventions as they arose, and to advise whether any form of control was likely to prove necessary in the public interest.

“While all will agree that industry should be alert to take prompt advantage of new methods made possible by the advance of science, yet it may be important in the public interest to graduate the rate of change to prevent too serious dislocations in the social order. A committee of this kind would have a difficult and responsible task, but could not fail to be helpful to the Government in advising it of the trend of change for industry in general and to inform it of possible dislocations of industrial life which may suddenly arise from the impact of scientific discovery.”

Speaking of national organisation for research in India in an address prepared for delivery at the Jubilee Session of the Indian Science Conference, he stated not long before his death:—

“In Great Britain the responsibility for planning the programmes of research even when the cost is borne directly by the Government, rests with research councils or committees who are not themselves State servants but distinguished representatives of pure science and industry. It is to be hoped that if any comparable organisation is developed in India, there will be a proper representation of scientific men from the universities and corresponding institutions and also of the industries directly concerned. It is of the highest importance that the detailed planning of research should be left entirely in the hands of those who have the requisite specialized knowledge of the problems which require attack . . .”

Likewise Rutherford was not unmindful of the influence of the results and speculations regarding the history and structure of the earth and the universe. Very early in his career he showed that Kelvin’s estimate of the age of the sun and the earth needed revision on account of the influence of radioactive energy, and he pointed out the method by which more reliable estimates could be obtained. His discussions with the aged Kelvin at the time bring out his innate courtesy and respect for the old.

In the foregoing, I have endeavoured to enumerate some of his achievements. I have not emphasised, as indeed he did not himself, all the honours bestowed on him. He was a Nobel Laureate. He received nearly 20 honorary degrees from universities of all countries. He was elected to the Order of Merit in 1925, and created Baron Rutherford of Nelson in 1931, and his heraldic arms bear witness to his New Zealand origin and subtly characterise some of his life work. When informed of this honour in 1931, he despatched the following characteristic cable to his mother in New Zealand: “Now Lord Rutherford. Honour more yours than mine.”

He honoured his father and his mother in the far away Antipodes and every two weeks he found time to write in his own hand a letter to his aged mother describing domestic happenings, events, functions and journeyings in such a way as to give her delight. These letters are an eloquent acknowledgment of the debt he owed to her early influence and training.

His personal qualities are, I think, best summed up in the following description by Sir William Bragg several years before his death:—

"He possesses a keen love of research for its own sake. He has a fine judgment of the essential, and goes to work in a way which, when the end is reached, is seen to have been obviously direct. His arguments and results are expressed in simple straightforward language which reveals the completeness and force of his thoughts. He has the courage to break with precedent and to try out his own ideas. Rutherford has upset many theories, but he has never belittled anyone's work. He has added new pages to the book of Physical Science, and has always taught his students to venerate the old, even when the writing has become a little old-fashioned. Perhaps it is by characteristics such as these, quite as much as by his own scientific perception and technical skill, that Rutherford exercises such a wide influence. He takes always a broad and generous view, giving credit to others for their contributions to knowledge, and never pressing for the recognition of his own. For this reason, his students have worked under him with loyalty and affection, knowing that their interests were safe in his hands. For this reason, too, he has friends among the scientific workers of every country, and is welcome everywhere. Even these qualities would seem to be insufficient for the international reputation he holds. In addition, he has a sound grasp of the essentials of business and a quick understanding of the thoughts and feelings of those with whom he is dealing. It has happened at more than one gathering that progress has been slow until Rutherford has taken the lead, and, with his driving power and natural kindness has brought about a successful issue. It is this unusual combination of so many qualities that has won for Rutherford a host of admirers."

His old colleague, Professor Geiger, in an address in Berlin in November last wrote:—

"How gladly I recall those years which I spent as a young man in Manchester in his laboratory. A very wide circle of young investigators was gathered there from all countries. The work was intensive, but over all our toil was an atmosphere of light-heartedness and joy in our creative work. For Rutherford's inspiration, his keenness in work, and his unshakeable belief in success carried us all with him. With the utmost willingness he gave from the rich store of his knowledge; he gave help and encouragement in all the small and great troubles which arise in experimental work. He never thought of himself, always of the task in hand and of his young friends, whom he let share in praise and recognition far above their deserts. His textbook on Radioactivity is for the initiated a record of his selflessness. How often does the name of a disciple accompany a discovery which was yet completely his own creation."

"Rutherford believed in co-operation in research. Everyone in his laboratory knew what the others were working on, and Rutherford himself explained most willingly the progress of his own researches and of the problems which impelled him. If he had success in a new experiment, we were all called into his workroom. And in wonder we stood around his apparatus and listened to his animated words, and carried away with us the memory of a great hour."

Such tributes from such men do not even do full justice to Rutherford's essential human characteristics as a man. It was his greatest charm that he could never be anything but himself. He knew his worth, but he always remained innately modest, simple and

without pose or pretence. He had extraordinary powers of concentration. He could work rapidly and for long hours, but at intervals he wisely shed all work and could enjoy a travel holiday to the full. He could flash fire on occasions, but neither as a youth nor in manhood did he ever sulk or bear malice. He took every opportunity of doing kindnesses to his friends and students and had a particularly warm spot for students from his home country who required help or guidance. In an age when science like industry is becoming less individualistic and when progress requires the organised efforts of many individuals, he displayed driving force and ability as an organiser, and through sheer inspiration of leadership encouraged the free development of initiative. There has never been a man in whom burning genius was so closely associated with kindly common sense, general sociability and the highest human qualities. Truly his was a life of service to his fellow men and to the ideal of truth.

E. M.

THE PUBLICATIONS OF THE LATE LORD RUTHERFORD.

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University of Otago.

The bibliography has been arranged chronologically, the date ascribed to the paper in question being the date of publication of the volume, number or part in which it appeared. Collaborators' names are given in brackets following the title of the paper. Titles of books are printed in italics. Standard contractions are used as far as possible for the journals cited. In citation the order of reference is series (Roman numeral), volume (Arabic numeral, heavy type), number or part (where necessary), page (Arabic numeral, normal type).

An endeavour was made to check each reference in detail, but this was not always possible, as some of the journals could not be consulted in New Zealand. It is hoped that any errors or omissions which inadvertently remain in the bibliography are few in number and of minor importance.

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Professor Sir Algernon Phillips Withiel Thomas, 1857-1937.

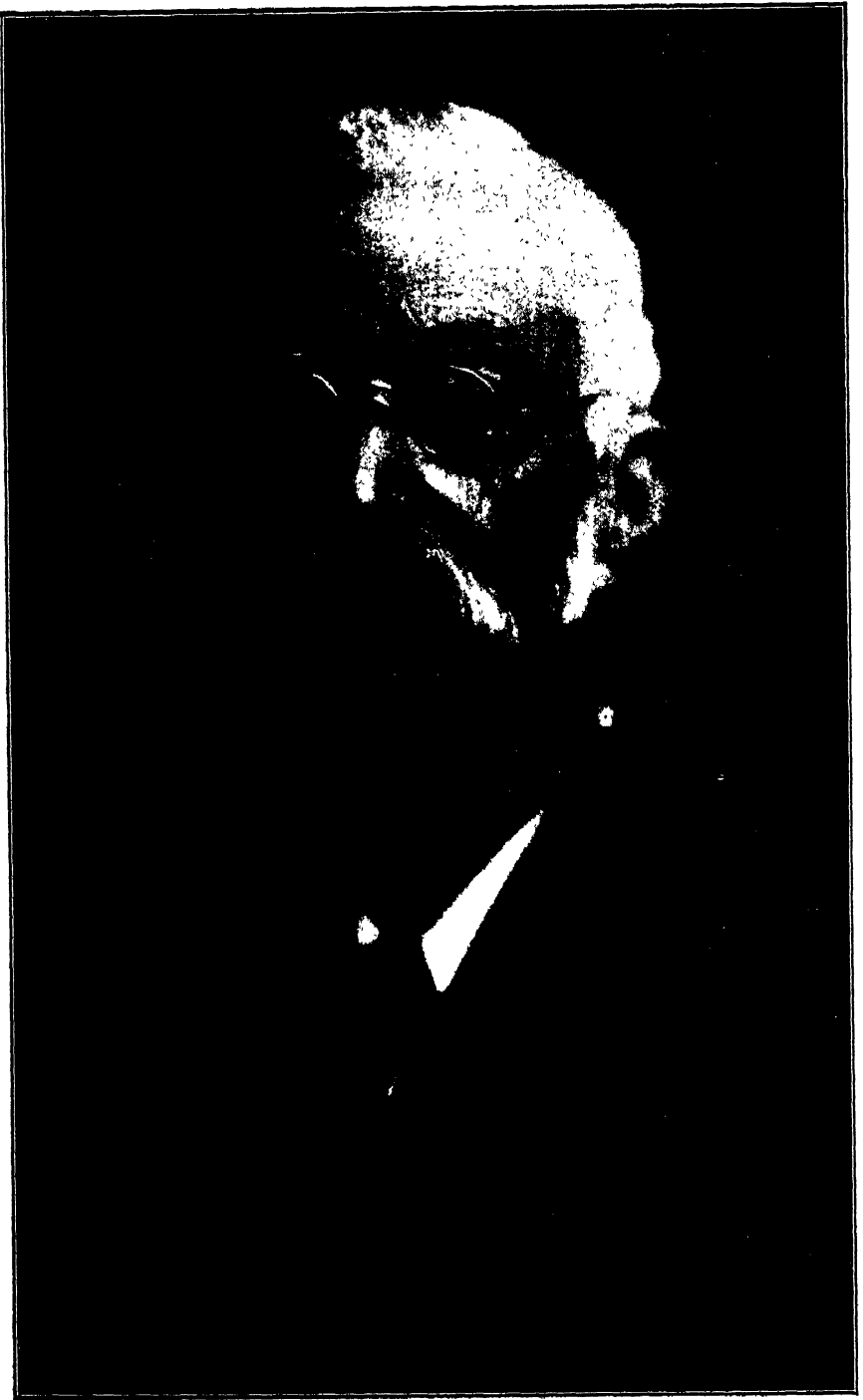
PROFESSOR THOMAS, an original Fellow of the Royal Society of New Zealand, died on the 28th December, 1937, in his eighty-first year and thus closed a long lifetime devoted to the cause of education and science.

Son of J. W. Thomas, of Illogan and Falmouth, best known in connection with the flotation of the Manchester Ship Canal, Sir Algernon was born at Birkenhead, Cheshire, on the 3rd June, 1857. He attended the Manchester Grammar School, whence he went to Balliol College, Oxford, as the holder of a scholarship in natural science. He graduated B.A. in 1877 with first class honours in natural science and also second class honours in mathematics. He won the Burdett-Coutts Scholarship of the University and took his M.A. in 1880. In 1880 he was appointed a demonstrator in biology on the staff of the University Museum, and it was while holding this position and still a very young man that he carried out his important research into the life history of the liver-fluke "long the despair alike of zoologists and agriculturists" and which, at that time, was causing enormous losses to British flocks of sheep. He made discoveries in this connection which were largely responsible for the success of efforts to subdue the pest.

When provision was made for establishing Auckland University College the young scientist, then aged 25, was selected as one of the original Professors of the College. Within his province were the chairs of Geology as well as both the branches (Botany and Zoology) of Biological Science. This tax on his energies did not prevent him also sharing in the teaching of mathematics during his first year in the emergency arising from the accidental drowning of the first Professor of Mathematics on the day of his arrival in Auckland, but it must have handicapped his efforts to achieve useful work outside his actual teaching. He was, however, a man of tireless energy and devotion to his work, and that his teaching was highly successful is attested by the successes of his students in all the subjects for which he was responsible.

Immediately after the great Tarawera eruption in 1886, Professor Thomas was engaged by the Government to make a full scientific report upon it. This publication is still regarded as the chief source of information on the eruption and its effects. Mr. Harry Lundius, of the Survey Department's Auckland District staff, who accompanied him on his journeys, is reported as saying: "Professor Thomas was one of the gamest little men I have ever met, a real plucky sort, and as dogged as they make them. He was ready in those days to tackle any difficult journey."

Another public service Professor Thomas rendered was as a member of a joint Australian and New Zealand commission on the rabbit pest. Prior to the establishment of the School of Mines, and the Bacteriological Department at the Auckland Hospital, he did an immense amount of gratuitous work in these departments.



The Late Professor Sir Algernon Thomas

Another activity that made Professor Thomas widely known was that of gardening. He was one of the first to carry out successfully the hybridising of narcissi. He raised many new varieties of daffodils, and in the season his display of daffodils drew visitors from far and near to his beautiful garden at Mount Eden.

Professor Thomas retired from his professorial duties at the end of 1913. He had become a member of the Auckland Grammar School Board in 1899. In 1916 he was elected Chairman of the Board and thenceforward a large portion of his time was taken up with the affairs of the Auckland Grammar Schools. During his association with the schools their number increased from one to five and the number of pupils increased from 250 to over 3000. The successful establishment of the additional schools and especially the lay-out of their grounds owed much to Professor Thomas' energy, skill and foresight. Amongst other positions Professor Thomas filled, it may be mentioned that he was a member and vice-chairman of the Dilworth Trust Board, an original member of the Board of Science and Art, a member for over 50 years of the Council of the Auckland Institute and Museum, President three times and Chairman of their Trustees for many years, and for some time a member of the Auckland University College Council and of the New Zealand University Senate. In his private life he was a keen and constant reader of the best literature in several languages and was perhaps equally interested in both Music and Pictorial Art. He had a remarkable memory and soundness of judgment, but there is no doubt that his work for the Grammar Schools was a major influence in creating a desire amongst his friends and co-workers that he should be honoured in the way that ultimately came about. In the Coronation Honours of May last he was made a K.C.M.G. and this tribute was warmly approved by public opinion and created enthusiasm amongst his friends. His investiture took place on December 14, only a fortnight before his death. Between the two events he had presided and spoken at no less than three prize-givings in a single day, as well as others before and after. Then his system seemed to decline to maintain further such activity and he sank peacefully to rest.

H. W. S.

Edward Phillips Turner, 1865-1937.

(Reprinted, by permission, from N.Z. Journal of Forestry.)

"THREE score years and twelve had left him as erect and trim as the trees of the sub-antarctic woodlands in which he spent his life of worth and effort.

He had dragged the chain and borne the theodolite in their survey, but their dark fastnesses became to him his cathedral, the stained windows in the forest heights lit with the gold of sunlight and the sapphire tints of the southern skies.

These woodlands he served throughout his life, for the service which they rendered to the people whom he equally served in courage and in faith.

A brave life; a true soul; an eye for the skies; a carriage distinguishing him in the forests of the world through which he trudged. Such was Edward Phillips Turner, a gallant gentleman, surveyor, forester."

E. H. F. SWAIN.

Those who met Phillips Turner in January last, when he presided over the Forestry Section of the A. and N.Z. Association at Auckland had no cause to suspect that it would be his last public appearance in forestry circles. His stride on the various excursions was vigorous as ever; his interest and enthusiasm still had the fire almost of youth, and it was scarcely apparent that he had just passed the allotted three score years and ten. Six months later a trifling injury to the foot irked him chiefly because it interfered with a botanical expedition planned for early winter. Then suddenly came the news of his death from blood-poisoning.

It is difficult to assess his influence on New Zealand forestry and New Zealand preservation of botanical monuments. He was the last of the old school of surveyors whose interest in their profession was largely the interest that the born natural historian finds in pioneering. In his case, the natural history bent was so obvious and paramount that for the major portion of his career his allotted duties were botanical rather than in direct connection with surveying, and from 1907, when he was appointed Chief Inspector of Scenic Reserves, both his interests and his duties were wholly in forestry. For just a quarter of a century, therefore, he exercised decidedly more influence than any other one man on New Zealand forestry and New Zealand's forests. No man ever sank his personality so completely in the forests that he served, forests that were at the one and the same time his hobby, his calling, his politics and his very creed.

His great regret was that he was not by training a professional forester and his characteristic modesty made him stress the point, often needlessly. It is known to but few that when in 1919 he was appointed head of the Forestry Department, he recommended that it be but a temporary appointment, until a professionally trained



THE LATE EDWARD PHILLIPS TURNER

forester could be secured. This done, he voluntarily relinquished his post and served as Secretary to the new State Forest Service for the next eight years. Such self-abnegation he conceived to be his duty in the interests of forestry, and it is worthy of chronicle as a record of his greatness. All were pleased when finally he was appointed Director of Forestry, a post which he valued as an honour, rather than for its emoluments. His retirement was devoted, as had been his active career, wholly to forestry interests and pursuits.

All foresters who knew him must feel his death as a personal loss. To the few who knew him intimately, his memory will be an abiding ideal of devotion to duty: single-hearted, selfless care for the well-being of the forest.

C. M. S.

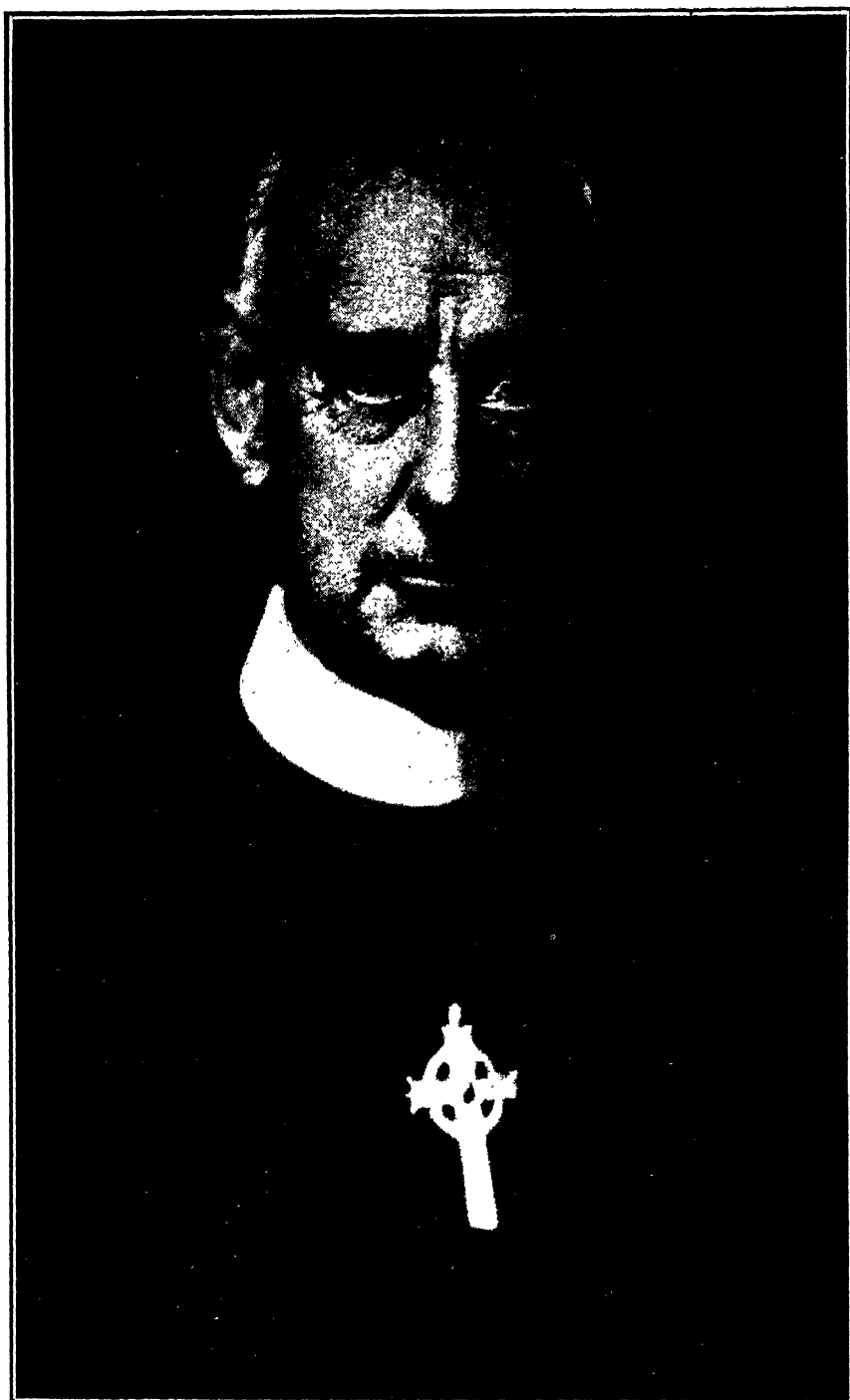
**The Right Reverend Herbert William Williams,
Bishop of Waiapu,
1860-1937.**

THE late Bishop Herbert William Williams was born in 1860 at Waerenga-a-hika, Poverty Bay, and began his education at Christ's College, Christchurch. Winning a University Scholarship, he took his B.A. degree at Canterbury College in 1880. From 1879 to 1880 he was resident at College House, Christchurch. He then went to Cambridge University, where he was a Rustat scholar, and graduated B.A. in 1884 and M.A. in 1887. While at Canterbury College he was a keen Rugby player, and at Cambridge he was captain of the Jesus College fifteen. After two years as a master at Haileybury College, he was ordained deacon in 1886, and priest the following year, and returned to New Zealand in 1889 to become vice-principal of Te Rau Native Technical College, Gisborne. Having held this office for five years, he was appointed principal, and remained at the college till 1902. From that year until 1929 he was Superintendent of Maori Missions on the east coast of the North Island, that term embracing the middle east, and in 1907 he was appointed Archdeacon of Waiapu. On the resignation of Bishop W. W. Sedgwick in 1929 he was elected Bishop, and was consecrated in St. John's Cathedral, Napier, on February, 1930, being the sixth occupant of the See.

He followed his father and his grandfather in his devotion to the Anglican Church; both preceded him as Bishops of the See of Waiapu. His grandfather, Bishop William Williams, who had joined the Reverend Henry Williams as missionary in New Zealand in 1826, was consecrated first Bishop of Waiapu in 1859. The son of William Williams, Bishop William Leonard Williams, was consecrated to the See in 1895, being succeeded in 1910 by the Right Reverend A. W. Averill, now (1938) Primate and Archbishop of New Zealand.

His grandfather was an excellent linguist, and it was his intellect, with that of other good scholars in the mission, that may be detected in the translation of the Bible into Maori. It was therefore appropriate that it should have been the Bishop lately deceased who, shortly before his elevation to the See, went to London to see through the press the most recent edition of the Bible. His grandfather also issued the first edition of the Maori dictionary, the grandson editing the fifth edition, published by the Government Printer in 1917. A Barotonga dictionary is near completion; the first part was in the hands of the Bishop at the time of his demise, and it is unfortunate that he will not be able to see this dictionary through the press as was intended.

The Bishop also edited the ninth and tenth editions of *First Lessons in Maori*, and the second edition of Grey's *Nga Mahi a nga Tupuna Maori*, which he largely revised and to which he added matter originally collected by Grey but not originally included. He produced a pioneer work of great intricacy—a Bibliography of Printed Maori, with supplement, and after completion of this, based on



The Late Bishop H. W. Williams.

printed books and leaflets in the possession of the late Alexander Turnbull and himself, he presented his collection to the Turnbull Library, making it easily the finest collection of Maori literature in existence.

In recognition of his work in the revision of the dictionary, and other literary activities, the New Zealand University conferred on him the degree of Doctor of Literature in 1924, and the Cambridge University did the same a year later. He was elected a Fellow of the New Zealand Institute (now the Royal Society of New Zealand) in 1923, and President of that Society in 1935, filling the office till 1937, when he was elected Vice-President. He was elected President of the Polynesian Society in 1929, holding that office, in which he was highly esteemed, at the date of his death. He was appointed a member of the Honorary New Zealand Geographic Board at its constitution in 1924, and that position, too, he held at the time of his death.

He was a member of the Polynesian Society for over forty years, and it was as a member and President of that Society that I, as its editor, came into closest contact, as also on the Geographic Board. His keenly critical mind led him to be extremely cautious as an editor; with the result, as I know, that hundreds of Maori words collected by men like Elsdon Best, S. Percy Smith, and lesser but not negligible collectors, were long scrutinised before being admitted to his dictionary. A very great many, though their collectors could supply good instances of their actual use, he refrained from admitting since their use had not been recorded by any one of the three generations of Maori dictionary-makers. Those words are therefore still without the pale, and hence there are many words, apparently good Maori, that have been or may be heard in use that will not be found in the dictionary. He subjected all names, particularly of course, Maori names, that might come before the Geographic Board to equally close scrutiny, and his critical aid, always readily given, will be much missed by New Zealand anthropologists, historians, and lexicographers.

In his long pastoral career Bishop Williams won a unique place in the esteem of the Maori, although, well as he knew the language, he seldom spoke through it. Speaking of him not long since, the Right Reverend Frederick A. Bennett, Bishop of Aotearoa, said: "His associates of the past followed Tane, the spirit of the setting sun, and he stands by himself as a lonely figure. No other pakeha occupies a similar position, and after he passes away no one will be left for the Maori to look to to give the sympathy, counsel, and

guidance that he can. He occupies a unique position in the love and respect of the Maori race."

Quite a short while before his death I had occasion to write to him in connection with a paper by him on Polynesian grammar to be published in the March Journal of the Polynesian Society. He sent the paper back with his comments, and said he had been advised to take three months' rest; but the characteristically cheerful tone of his letter gave me no hint that there was anything serious. I was about to leave for the south, to a complete change of scene; and I wrote: "I hope you will enjoy your rest, and that you are looking forward to a complete change as I am." That was on 4th December. But he could not cease work even when resting; on the evening of Monday, 7th December, he had a meeting with several co-workers about his bed; he started to read the minutes; he put them down and said he could not go on; he had a seizure, and in a few minutes had passed away. My letter was returned by his son, the Reverend Nigel Williams.

J. C. A.

TRANSACTIONS

Fruit Characters in the F₂ of a *Coprosma* Cross.

By H. H. ALLAN, Plant Research Bureau, Wellington.

[Read before the Wellington Branch, 22nd September, 1937; received by the Editor, September 6, 1937; issued separately, June, 1938.]

IN two earlier papers (Allan, 1926 and 1929) the first generation arising from the artificial crossing of wild plants (*in situ*) of *Coprosma propinqua* (female) with *C. robusta* (male) was described, and the vegetative segregation in the second generation discussed. Here is illustrated the remarkable range of fruit colour secured in these plants. For the faithful rendering of the colours, shapes and sizes I am greatly indebted to Miss Eunice Reekie (figs. 1-6).

In the following table are given the statements of Cheeseman (1925) and Oliver (1935) for the fruit characters, together with my own findings for the plants worked with by me.

As to the arrangement of the flowers and fruits the only points of difference are that Cheeseman includes plants with small fascicles in *C. propinqua*, and that Oliver apparently does not admit solitary flowers in X *C. Cunninghamii*. Cheeseman did not definitely accept the hybridity of *C. Cunninghamii*, whereas Oliver does. I agree with Oliver in finding only solitary flowers in true *C. propinqua*, but have also found solitary flowers to occur both in F₁ and F₂ of the hybrid progeny. For shapes and sizes of fruits the differences in the three descriptions are not very significant, and do not cover the whole range actually to be found. But while Oliver definitely classes the fruits of *C. propinqua* as globose, I have rarely seen truly globose fruits in this species, and never as the prevailing shape on any specimen.

While field observations show that in both *C. robusta* and *C. propinqua* jordanons with somewhat differently coloured fruits occur, and that the determination of fruit colour is influenced by the stage of maturity the fruits have reached when examined, our findings are in practical agreement for these two species, the two standing markedly apart in fruit colour. With regard to *C. Cunninghamii* we are distinctly at variance. Comparing this with *C. robusta* Cheeseman (*loc. cit.*, p. 861) says, "Intermediate states are not uncommon, and are often difficult to place in the absence of fruit." He thus relies on the "pale and translucent" drupe as the essential point of difference. Oliver (*loc. cit.*, p. 179), recognising unreservedly the hybridity of *C. Cunninghamii*, and using that name to cover *all* the hybrid forms (*i.e.*, not using the name in the restricted sense that Cheeseman adopts) states: "The fruit is globose or oblong and translucent, thus lacking both the red colour of *C. robusta* and the blue of *C. propinqua*."

Fruit characters.	ROBUSTA			PROPINQUA			CUNNINGHAMII		
	Cheeseman	Oliver	Allan	Cheeseman	Oliver	Allan	Cheeseman	Oliver	Allan for F_1
Arrange- ment ..	dense peduncled glomerules	compound peduncled clusters	compound peduncled clusters	solitary, or 2-4 flowered fascicles	solitary	solitary	in 3-12 flowered glomerules	as in <i>robusta</i> , but fewer per cluster	solitary or in 2-5 flowered clusters
Colour ..	yellowish- or orange-red	dark orange-red	scarlet	bluish or bluish-black or black	pale blue speckled with dark blue	bluish-black with small semi-translucent patches speckled blue	pale and translucent	translucent	mostly pale and semi-translucent with few blue specks
Shape ..	oblong to ovoid	oblong or narrowly ovate	oblong-elliptic in outline	globose or broadly oblong	globose	subglobose to broadly oblong-elliptic in outline	broadly oblong	globose or oblong	broadly oblong-elliptic in outline to subglobose
Size ..	$\frac{1}{4}$ to $\frac{3}{4}$ in. long	8-10 mm. long, 4-5 mm. broad	8-10 mm. long, 4-5 mm. broad	$\frac{1}{3}$ in. long	7 mm. diam.	6-7 mm. long, 4-5 mm. broad	$\frac{1}{4}$ in. long	—	5-6 mm. long, 4 mm. broad

Fruit colour in the F_1 females raised by me was described (Allan, *loc. cit.*, 1929, p. 335) as follows: "On most plants the fruits were pale and translucent, with few or no purple flecks, thus matching the description of Cheeseman (*Manual N.Z. Flora*, 1925, p. 861) for *C. Cunninghamii*; on others they had more purple and approached those of *C. propinqua*, while on a few they were yellowish, and on one almost orange, thus approaching *C. robusta*."

My second generation flowered and fruited abundantly in 1934 and subsequent years. Of the 54 plants 26 proved to be female. No one plant had exactly the same fruit colour as another. On the basis of the charts published by the Société Française des Chrysanthémistes (1905), the ground colours may be approximately grouped as varying shades of: milk-white, yellowish white, greenish white, sulphur-yellow, buttercup-yellow, yolk-yellow, chrome yellow, Indian yellow, scarlet orange, red orange, and tomato-red. In all but the scarlets and reds, and even faintly in some of these, there was more or less spotting with cornflower to prussian blue, and in one or two examples the main colouring was a deep prussian blue. Fruits with the very pale colours were semi-translucent.

The arrangement graded from solitary fruits to rather large, dense, compound clusters. The shapes covered those of the parent species and were fairly constant for any one plant, while there was the same range of size. The number of plants available is too small to justify any attempt at detailed factorial analysis, but there appears to be a distinct tendency for greater leaf-size to be associated with greater degree of clustering, and a rather less-marked tendency for the clustering to be associated with the red colour derived from *C. robusta*. Fruit-size and shape apparently segregate independently of fruit colour. Cockayne and Allan (in Cockayne and Turner, 1928, p. 142) suggested the name *X C. prorobusta* for the whole group of hybrids found in nature between the two species, and the restriction of the name *X C. Cunninghamii* to those forms closely approximating to the original description of Hooker. Oliver (*loc. cit.*, p. 179) uses *X C. Cunninghamii* for the whole group, treating the name *X C. prorobusta* as a synonym. The point is perhaps of no great importance, but if the name *X C. Cunninghamii* be adopted for the whole group, the second generation here described shows that Oliver's statement as to fruit colour cannot be retained. Of wild hybrids, too, the most that can be said is that pale semi-translucent drupes, possibly mainly on F_1 plants, appear to be more plentiful than the more highly coloured ones.

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LEGEND OF ILLUSTRATIONS.

FIGS. 1-6.—Fruit colour in F_2 *Coprosma* hybrids. Drawn by E. Reekie.

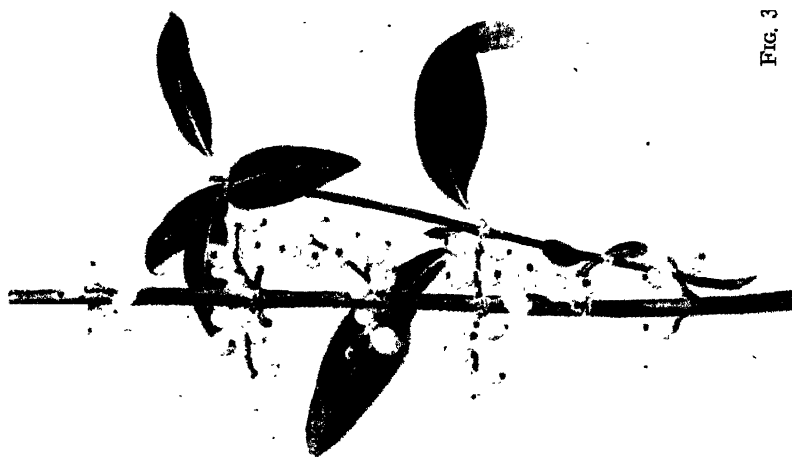


FIG. 3

Drawn by E. Reebie



FIG. 1.



FIG. 2.

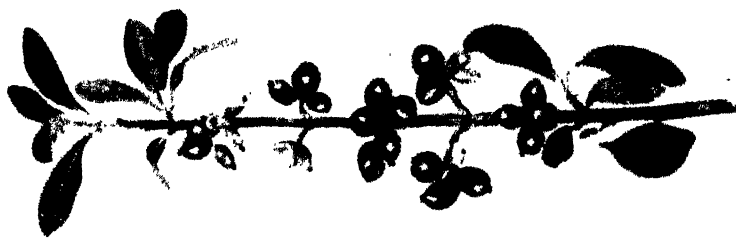
FRUIT COLOUR IN F₂ COPROSMA HYBRIDS.



FIG. 4.



FIG. 5.



Drawn by E. Reekie

FRUIT COLOUR IN F_2 COPROSMA HYBRIDS.

The Plumages of *Nesonetta aucklandica* Gray.

By R. A. FALLA and E. F. STEAD.

[Read before Canterbury Branch, Royal Society of N.Z., September 1, 1937; received by the Editor, December 15, 1937; issued separately, June, 1938.]

EXISTING descriptions and coloured figures of *Nesonetta aucklandica* Gray are alike defective in that they fail to define the distinctive plumage characters of male and female and to indicate the close correspondence of plumage pattern and moult sequence of this duck with those of *Anas chlorotis* Gray.

Gray's description of *Nesonetta aucklandica* (1845, 16) is too brief to have much comparative value and could not apply to an adult male in breeding plumage. The plate (1845, pl. 17), presumably of the type, shows none of the gradations of brown on the sides and flanks nor the contrasty blackish under tail coverts of the adult breeding male. Buller's plate (1888, vol. II, pl. XLII) shows an immature bird or an adult female. His accompanying description (1888, p. 263) can also apply only to a female, or male in full eclipse plumage. In a later account, Buller (1905, p. 14) states that "the sexes do not differ much from each other, both exhibiting the delicate reflections on the plumage of the upper parts, but the male may be distinguished by its darker head and neck, by the black under tail coverts and by a greater abundance of vermiculated markings on the sides of the body." As a female of this duck never shows any vermiculated feathers this remark seems to indicate that Buller was not familiar with the distinctive plumage of the sexes. The sexing of skins made by commercial collectors in New Zealand can seldom be relied on; an undoubted male skin in the Buller collection in the Canterbury Museum (No. 0.1219.5) bears a label in Buller's handwriting accepting it as a female. As Oliver (1930) describes the female as having "vermiculations on side of body less marked" the matter is no further advanced.

The adult male here described is taken to be in nuptial plumage. It is in the collection of the Canterbury Museum (No. 0.1219.3), has no data attached except sex and locality. It has been mounted since 1910 and appears to be one of the birds collected by the late Edgar R. Waite at the Auckland Islands in June, 1912. Specimens labelled with date and indication of careful sexing seem almost impossible to find in the long series of specimens of this duck distributed in collections all over the world. A description of the male plumage follows:—

Head and neck sepia, dull on foreneck and very slightly mottled with pale buff on the chin, warmer in tone, admixed with black, and glossy on cheeks and crown; patches of glossy green commencing behind the eyes and spreading caudad on to the hind neck where they meet, ending level with the sepia area of the foreneck. The upper breast and sides of breast bright russet shading to tawny on lower breast and flanks, the feathers of this region being obscurely

marked with subterminal spots of dark sepia. The belly presents a mottled appearance, feathers being tawny with a large central spot (and sometimes bars) of sepia, and pale edges, and much more distinctly barred on thighs and under tail coverts. The general colour of back, wings and tail is dark sepia, but on mantle and scapulars, as on the flanks, are finely vermiculated feathers of sepia and whitish buff. In a few of these feathers on the thighs the whitish buff becomes pure white, forming sharp contrast with the black under tail coverts. When the wing is viewed from behind there is a definite speculum caused by the distinct oil-green gloss on the outer webs of most of the secondaries, which are edged with pale cinnamon and white. A gloss of the same green is noticeable on upper wing coverts, upper tail coverts, rump and some of the scapulars and mantle. Some of the outer scapulars have their outer webs edged with black. Tail coverts dark sepia edged with dark tawny. Primaries sepia, lighter on inner webs.

The following description of a female is taken from a bird collected at the same time as the male described above. The correctness of the sexing in this case is confirmed by its similarity to an adult female collected at Ewing Island, Port Ross, Auckland Islands, in March, 1923, by G. Archey; this bird was preserved in spirit and recently dissected by one of us (R. A. F.).

There are no vermiculations anywhere at any stage. The head is generally sepia, but without gloss except slightly purplish on the crown. The chin, throat and foreneck are more distinctly mottled with white than in the male. Breast and flank feathers Saccardo's umber at the base merging to tawny olive at the edges, without subterminal spots. By a transition well defined from the lower breast, the belly feathers are sepia broadly edged whitish. Under tail coverts sepia with indistinct lighter edges. Upper parts dark sepia with scapulars edged with tawny, the whole of the upper surface having a green gloss similar to that of the male but fainter; speculum less distinct, the outer webs of the secondaries having only the same amount of gloss as the rest of the upper surface.

The series of spirit specimens in the Canterbury Museum is further valuable as indicating that males undergo an eclipse plumage. Of six specimens collected at Port Ross in March, 1923, five are males. They lack the decorative features of the male plumage taken in June and early spring, and only here and there are odd vermiculated feathers to be found hidden in the rest of the plumage. Otherwise these birds have a general resemblance to females, but differ in their greater size, absence of distinct whitish throat patch, and by having more or less barred and mottled feathers on the belly where those of the female are plain sepia edged with dull white. Particulars and dimensions of this Ewing Island series (collected by G. Archey, March, 1923) are as follows. (Tail measurements are omitted owing to variable abrasion. The moult referred to is the body moult.)

No.	Sex.	Wing.	Tarsus.	Toe.	Culmen.	Notes.
1219.7	♀	125	32	45	35	adult, moulting
1219.8	♂	125	37	52	40	adult, moulting
1219.9	♂	130	35	50	40	adult, moulting
1219.10	♂	127	36	48	39	immature
1219.11	♂	135	35	50	40	adult, moulting
1219.12	♂	125	35	51	38.5	immature

It has not been sufficiently emphasised that in the nuptial male plumage there is no essential pattern difference between *Nesonetta aucklandica* and *Anas chlorotis*. Plumages are variable in the latter species, and the general tone is usually a shade lighter than in *Nesonetta*. The males of the two species show a closer resemblance than females and immature birds, but there is not sufficient material available in collections to decide on the exact degree of resemblance.

Descriptions of New Species of New Zealand Hepatics, II

By TH. HERZOG, Jena University.

[Received by the Editor, January 10, 1938; issued separately, June, 1938.]

INTRODUCTION.

(By E. A. HODGSON.)

IN these descriptions of New Zealand hepatics, together with the footnotes which I have translated from the German, we have another valuable addition to our literature on hepatics. With so much of our natural vegetation destroyed, one marvels that so many new species should be so constantly appearing, and we are pleased that these interesting and endemic plants are being scientifically described in a New Zealand journal.

The three figures of *Lepidoziae* on Plate 4 represent critical species already described by Fr. Stephani in *Species Hepaticarum*. Regarding *L. parviterata* St., Dr. Herzog states in a recent letter that he has seen the original of this and that it is merely a form of *L. breviloba* St.

Jamesoniella inflexo-limbata Herz.: Miss Moore, who collected this plant, states that it often forms a mat a square yard or more in extent on sloping rock.

Plagiochila elegantissima Herz.: This plant is one of a fine collection of hepatics gathered by school children at Rarotonga; kindly sent by Miss Cranwell, and now in the Auckland Museum.

Plagiochila subquadrata Herz.: This species has also been collected "in fringe of bush, Toa Toa, 1000 ft., B. of Plenty," by Mrs. I. Haskell.

Lepidozia cavernarum Herz.: This has been distributed in Hepaticae Exsiccatae Novae Zelandiae under the name of *L. cavernicola* Herz. (ined.). It is not uncommon in the Wairoa district at any rate, and at Waikaremoana it is often to be found on damp, shady, crumbly banks. There is a little of this in a packet of *Anthoceros* leg. T. Kirk, now in the herbarium of the Plant Research Bureau.

Lepidozia bisetula Herz.: This is also fairly common in bush, usually associated with other bryophytes. I have gatherings by Mr. K. W. Allison from the Atiamuri district, also from Wairau-moana, Waikaremoana, leg. Mrs. G. O. K. Sainsbury.

Plagiochila limpida Herz.: There is a fine fruiting specimen of this plant in Colenso's collection in the Napier Museum. Also collected by K. W. Allison "by Ongaroto Road, Atiamuri district." A terrestrial species.

Physocolea Hodgsoniae Herz.: The little remnant of bush in which this species was found, and the only known locality, has since been cut and burnt.

DESCRIPTIONS OF SPECIES.

Jamesoniella inflexo-limbata Herz. n.sp.

Dioica (planta ♀ tantum visa); minor, gracillima, pulvinatum (?) caespitosa, grisea. Caulis ad 2 cm. longus, filiformis, erectus, subsimplex, teretiusculus, julaceus. Folia laxè imbricata, concavissima, cymbiformia, suborbicularia, diametro ca. 0, 4 mm., limbo hyalino, demum corroso, inflexo circumducta, integerrima; cellulae ubique fere aequimagnae, subrectangulari-hexagonae, a medio ad basin subseriatae, ca. 18 μ longae, 16 μ latae, diaphanae, tenerrimae, trigonis nullis vel minimis, marginales in una serie radialiter parum elongatae, emortuae, hyalinae, cuticula ubique laevi. Folia floralia majora, variegata breviter lacerata, liciniis obtusiusculis; amphigastrium florale parvum, angustum, variegata repandum, obtusum. Perianthium clavatum, ca. 1, 2 mm. longum, apice breviter pluriplicatum, ceterum laevissimum, ore contracto plurilobulato, lobulis obtusis, hic illic minute denticulatis.

Rocks of crater rim, Mount Tongariro, National Park, leg. L. B. Moore, 12.I.33 (n. 130).

Similar to *J. teres*, but differing in the softer leaves, and in the leaf margin, which subsequently becomes erose as in some species of *Marsupella* and *Gymnomitrium*, and in the perianth being plicate at the mouth only.

Plagiochila elegantissima Herz. n.sp.

Sterilis; major, laxè caespitosa, flaccida, viridis. Caulis subsimplex, 3–4 cm. longus, rufescens, cum foliis ca. 5 mm. latus. Folia sub angulo ca. 45° patula, parum concava, subdistiche expansa, ad 4 mm. longa, 2 mm. lata, e basi utrinque parum decurrente, obconica oblongo-semiovata, margine utroque basi anguste revoluta, postico caulem dimidium vix tegente, basi integerrima, superne sat regulariter longe spinoso, spinis 11–13, oblique porrectis, strictis vel curvatis, 5–7 cellulas longis, antico supra medium paucispinoso, spinis 4–5 brevioribus, apice angusto, similiter armato; cellulae ubique fere aequales, diametro ca. 36 μ , diaphanae, tenerrimae, trigonis parvis. Amphigastria caulina minima, rudimentaria, variegata lacinulata.

Rarotonga, Cook Islands, leg. Hamilton.

A conspicuous and elegant plant with its large and somewhat semi-ovate leaves which are inserted at an angle of less than 45°, and have wedge-shaped bases and spinous upper margins. Characteristic also is the very soft, lax areolation. Cannot be compared with any known species.

Plagiochila calcarata Herz. n.sp.

Sterilis, major, viridis, fuscescens, nitidula (habitu *Pl. chilensem* aemulans). Caulis ad 7 cm. longus, cum foliis ca. 4 mm. latus, sat laxè fastigiatim ramosus, flexuosus, brunneus. Folia caulina distiche patula, sub angula 50–60° patentia, sat complanata, late inserta, ca. 2 mm. longa, 1, 3 mm. lata e basi postica parum ampliata, caulem tegente et saepius reflexa oblongo-triangulari, apice ablique truncata, margine antico e basi parum decurrente substricto vel longe sinuato,

sub apice 1-2-dentato, postico basi rotundato-ampliata ibique longe spinoso, spinis varie patulis, rectis vel subhamatis, saepe uno majore, quasi calcariformi, superne stricto, subintegerrimo, sub apice unidentato, dente valido, spiniformi, apice grosse trispinoso, spinis oblique porrectis, antico grossiore. Cellulae apicales diametro ca. $27\ \mu$, trigonis maximis, nodulosis vel trabeculiformi-elongatis, in parietibus longioribus subconfluentibus, basales $25 \times 50\ \mu$ metientes, trigonis magnis nodulosis, valide trabeculatae, anulo chlorophyllifero lato, distincte granuloso. Cetera desunt.

Marlborough, leg. J. H. McMahon (E. A. Hodgson mis., sub no. 17).

In appearance this species resembles *P. chilensis*. It is characterised by the spur-like spines of the rounded posterior leaf-base, which are separated from the coarse and straight apical teeth by a more or less entire margin.

***Plagiochila limpida* Herz. n.sp.**

Sterilis (planta ♂ tantum visa); dense caespitosa, mollis, pallide glauco-viridis, opaca (habitu *Distichophyllum* quodam aemulans). Caulis subsimplex vel parum ramosus, adscendens, turgidulus, ca. 2-3 cm. longus, cum foliis ca. 2, 5 mm. latus, tenuis, tamen carnosus, viridis. Folia caulina sub angulo ca. 45° patula, concava, deversa, asymmetrica, subrotunda vel late trigona, 1-1, 3 mm. longa et lata, margine antico parum decurrente, leviter arcuato, integerrimo, margine postico e basi rotundato-ampliata, caulem tegente alte arcuato, ubique sat regulariter ciliolato-spinoso, ciliis recte patulis vel parum hamulatis, ad 5 cellulas longis, cellulis ultimis hyalinis, apice late rotundato, similiter armato (ciliis in folii margine omnino ca. 15). Cellulae apicales diametro ca. $36\ \mu$ basales $36 \times 50\ \mu$ met., annulo chlorophyllifero angusto, ceterum hyalino-limpidae, trigonis nullis, parietibus tenerrimis. Androecia mediana, repetita, bracteolis ad 11-jugis, pungenti-spinulosis.

On ground in bush by Makaretu Falls, Wairoa, leg. E. A. Hodgson (n.l.).

A very pretty species which at first sight recalls a *Distichophyllum*. Distinguished by the leaf-shape, soft areolation and ciliate-toothed posterior margin and apex.

***Plagiochila lonchoscypa* Herz. n.sp.**

Pro gente parva, gracilis, tamen rigidula, rufescens, ut videtur erecta, dense caespitosa, dite fertilis. Caulis ad 2 cm. longus, e basi valde fasciculato-ramosus, superne furcatus, id est sub flore ♀ his innovatus, cum foliis ca. 1-1, 5 mm. latus. Folia erecto-patula, sub angulo ca. 40° oblique inserta, a latere parum compressa, 0, 8 mm. longa, 0, 6 mm. lata, e basi parum decurrente, conico-angustata semi-ovata, margine antico leviter arcuato vel substricto, integerrimo, postico e basi truncata modice arcuato, spinis ca. 5 longis, porrectis, flavidis armato, apice oblique truncato, acuto spinis 2 longis, antico longiore, prorsus spectante. Cellulae apicales diametro ca. $16\ \mu$, basales parum majores, ca. $16 \times 24\ \mu$ metientes, trigonis ubique majusculis, nodulosis, chlorophyllosae. Folia floralia majora, peri-

anthio a latere appressa, basi antica longe decurrentia, margine postico et apice grosse longeque flavo-spinosa. Perianthia longe exserta, elongata, 2, 2 mm. longa, ambitu subspathulato-elliptica, exalata, basi gibbosa, superne arcte complanata, ore parum angustato, longe spinoso.

On *Quintinia*, Mt. Moehau, 2700 ft., Coromandel, Auckland. 31.XII.33 (n. 8).

This new and attractive-looking species is easily recognised by its forked stem, longly-exserted, slender perianth with spinous-toothed mouth, and also by its small spinous leaves.

***Plagiochila subquadrata* Herz. n.sp.**

Major, late caespitosa, obscure viridis, opaca. Caulis ad 9 cm. longus, lax fastigiatim ramosus, cum foliis ca. 4 mm. latus, parum convexus. Folia sub angulo ca. 50° patentia, subremota, concaviuscula, parum deversa, humida tamen fere explanata, basi haud ampliata, inferiora ambitu subquadrata, ca. 1, 5 mm. longa et lata, superiora breviter rectangulata, ca. 2 mm. longa, 1, 5 mm. lata, vix decurrentia, margine antico substrieto, parum inflexo, integerrimo, postico e basi truncata leviter arcuato, remote spinoso-dentato, dentibus basi late triangulari, apicem versus sensim majoribus, recte patulis, apice late recteque truncato, aequaliter dentato, dentibus 3, recte patulis. Cellulae ubique fere aequales, chlorophyllosae, apicales ca. 16 x 18 μ , basales 18 x 27 μ metientes, trigonis et incrassationibus intermediis modicis, subacutis vel nodulosis. Folia floralia longiora, subelliptica, magis decurrentia, longius spinosa. Perianthia campanulata, compressa, brevia, ore late rotundato, longe denesque laciniato, laciniis e basi triangulari acuminatis, spiniformibus.

Marlborough (South Island), leg. J. H. McMahon, XII.32 (mis. E. A. Hodgson).

A fine species, well distinguished by its particularly broad, obtuse, coarsely toothed leaf-apex and the general leaf shape, which is short in proportion to its breadth. Unfortunately, its habitat is not noted. Probably corticolous.

***Lepidozia Allisonii* Herz. n.sp.**

Sterilis; humillima, dense caespitosa, viridi-fusca. Caulis primarius rhizomaticus, secundarius suberectus, sparse ramulosus, ca. 5 mm. longus, filiformis, ramis haud flagelliformi-attenuatis, eleganter catenulatus. Folia caulina minima, 0, 18 mm. longa, 0, 16 mm. lata, subtransverse inserta, laxe accumbentia, concaviuscula, laciniis parum incurvis, subsymmetrica, ad $\frac{3}{4}$ quadrifida, laciniis subparallelis, incurvo-porrectis, sublingulatis, ubique fere 2 cellulas latis, obtusiusculis, sinibus angustissimis, rimaeformibus, disco integro humili, 2 cellulas alto; cellulae laciniarum suboppositae, geminatae, ultimae tantum singulae, diametro ca. 15 μ , basales vix majores, ubique validae, trigonis nullis. Amphigastria caulina subaequalia (saepius trifida).

Damp hollow in tussock land E. of Taupo, leg. K. W. Allison, 2.XII.33 (n. 227).

The distinguishing characteristics of this small pretty plant are the leaf-segments which are 2 cells wide from the base to the apex and of almost uniform breadth, also the surprising regularity of the cells which simulate a transversely articulated band.

Lepidozia bisetula Herz. n.sp.

Sterilis; minima, gracillima, capillacea, subhyalina. Caulis ad 10 mm. longus, irregulariter ramosus, flexuosus. Folia caulina subremota, transverse inserta, divaricato-patula, ad basin fissa, bisetula, setulis late divergentibus, substrictis, unam cellulam latis, 5 cellulas longis, ca. 0, 3 mm. longis, cellulis basalibus ca. 90 μ longis, 20 μ latis, sursum sensim brevioribus, hyalinis, chlorophyllo ad parietes transversas tantum obvio. Amphigastria caulina foliis plus duplo breviora, ad basin bisetula, setulis 3 cellulas longis, apice hamatis, conniventibus, e basi rhizoidia singula emittentia. Cetera nulla.

Russell, Bay of Islands, North Island, leg. V. W. Lindauer (n. 281).

Resembling an *Arachniopsis*, but with stipules distinctly developed.

Lepidozia cavernarum Herz. n.sp.

Dioica, ♀ planta tantum visa; minima, caespitosa, pallida, inter alias hepaticas repens. Caulis irregulariter et parce ramosus, vix 10 mm. longus, rhizoidibus e caule primario subaphyllo longissimis, hyalinis ortis. Folia caulina subremota, squarrose patula, ad 0, 4 mm. longa, subsymmetrica, ad $\frac{3}{4}$ (in rameis ad $\frac{1}{2}$) bifida, laciniis leviter divergentibus vel in situ parum conniventibus, anguste lanceolatis, acuminatis, basi 3 cellulas latis, in acumen uniseriatum, 3 cellulas longum exeuntibus, sinu obtusiuscula, disco integro obconico, basi 4-5 cellulas lato, 2 cellulas alto, integerrimo; cellulae ubique elongate rectangulares, ad 80 μ longae, 20-30 μ latae, validae. Amphigastria caulina ad 0, 2 mm. longa, caule vix latiora, laxa patula, ad $\frac{3}{4}$ bifida, bisetula, setulis 2-3 cellulas longis, disco integro 1 cellulam alto, 2-3 cellulas lato. Flos ♀ subsessilis, basi longe rhizoidiferus, 1, 2 mm. longus. Folia subfloralia et floralia caulinis multo majora, ca. 1, 2 mm. longa, 0, 65 mm. lata, libera, subovata, ad medium bifida, laciniis late lanceolatis, acuminatis, utroque margine spinoso-lacinulatis, disco integro margine parce obtuse dentato; amphigastrium florale oblongum vel anguste rectangulare, quam folia brevius, ad $\frac{1}{2}$ bifidum, laciniis breviter acuminatis, subconniventibus, margine repandis (Perianthium nondum evolutum, vallo humillimo archegonia ca. 8 circumdans).

In hole in hill, "Kiwi," Wairoa, leg. E. A. Hodgson, Sept., 1931 (n. 88).

L. tasmanica is the only one of the bifid-leaved Lepidoziae with which this can be compared, but our plant differs in the shallower sinus, in the leaf-segment being 3 cells broad at the base, and in the free, differently shaped involueral leaves.

***Lepidozia digitata* Herz. n.sp.**

Sterilis; minor, dense depresso-caespitosa, pallida, brunnescens. Caulis decumbens vel adscendens, laxe pinnatus, ca. 1 cm. longus, pinnis 2–3 mm. longis obtusis. Folia caulina subremota, parum concava, humida explanato-disticha, fere longitudinaliter inserta, ad 0, 4 mm. longa, 0, 35 mm. lata, subrotundo-ovata, asymmetrica, ad $\frac{1}{2}$ quadriloba, lobis anguste lanceolatis, palmatim expansis (anticis 2 plerumque approximatis), basi 2 cellulas latis, margine folii postico brevi substricto, antico duplo longiore, valde arcuato, disco integro integerrimo; cellulae ubique fere aequales, apicales diametro ca. $2\frac{1}{2}$ μ , mediae 24×40 μ , basales $2\frac{1}{2} \times 50$ – 60 μ metientes, subopaco-brunneolae, parietibus strictis, validiusculis, trigonis subnullis, cuticula minutissime et densissime punctulata. Amphigastria caulina cauli subaequilata, ad medium 3–4-loba, lobis 3–4 cellulas longis, basi 2 cellulas lata excepta ubique 1 cellulam latis, obtusiusculis, disco integro latissimo, humillimo, 2 cellulas alto, cuticula aequaliter punctulata.

Shady bank near waterfall, near Atiamuri, leg. K. W. Allison (n. 72).

Distinguished from the other *Lepidoziae* with asymmetrical 4-lobed leaves, by the peculiar form of the leaf, the large brown leaf-cells, the cuticle not dotted, also by the very small stipules.

***Lepidozia leptodictyon* Herz. n.sp.**

Dioica; tenera, minuta, dense pulvinatim caespitosa, brunneola. Caulis ca. 10 mm. longus, irregulariter ramosus, teneriter tamen carnosus. Folia caulina subtransverse inserta, sat densa, laxe incurvo-accumbentia, concaviuscula, 4- (vel 3-) fida, subsymmetrica, laciniis e basi 4–6 cellulas latis late lanceolatis, breviter acuminatis, disco integro magno, integerrimo, utroque margine leviter arcuato; cellulae ubique diaphanae, hyalinae, mediae 30×40 – 50 μ metientes, basales ad 60 μ longae, ubique tenerrimae (unde nomen!), trigonis nullis. Amphigastria caulina 0, 3 mm. longa, 0, 2 mm. lata, ad medium 3- (vel 2-) fida, lobis angustissimis, basi 2 cellulas latis. Flos ♀ longiuscule pericellatus. Folia floralia tenerrima, 1, 3 mm. longa, 0, 6 mm. lata, anguste oblonga, ad $\frac{1}{2}$ 3-fida, lobis inaequalibus angustis, porrectis vel conniventibus, disco integro longo, superne utrinque 1-dentato. Amphigastrium florale liberum, aequilongum, 2-fidum, foliis conforme. Perianthium longe exsertum, 3 mm. longum, 0, 8 mm. crassum, vitreum, obtuse trigono-cylindricum, triplicatum, apice breviter trilobum, lobis varie lacinulatis. Androecia longe spicata, vermicularia, bracteis multijugis, concavissimis, 3-fidis; amphigastria foliis caulinis simillima.

Edge of swamp, near Atiamuri, c. 1000 ft., leg. K. W. Allison, 18.VII.29 (n. 70).

Remarkable for its delicate structure and the large leaf-cells. In spite of the thin walls, the whole plant is somewhat fleshy.

***Physocolea cucullifolia* Herz. n.sp.**

Monoica; exigua, subhyalina, corticola. Caulis ad 5 mm. longus, irregulariter drite ramosus, repens. Folia subremota, ovato-rotundata, parum concava, tamen apice cucullata, 0, 4 mm. longa, 0, 35 mm. lata,

ubique celluloso-crenulata vel papulosa; cellulae turgide prominulae, ubique fere aequales, hexagonae, diametro ca. $18\ \mu$ subhyalinae, tenerrimae; lobulus maximus, folio subaequilongus, subgloboso-saccatus, apice angustato, in folii marginem apicalem attenuato, protracto, emarginato, angulo spina 2 cellulas longa, oblique porrecta armato, spina cum folii cucullo subcontiguo orificium sacculi cingente; stylus nullus vel haud perspicuus. Folia floralia aequilonga, angustiora, oblonga, obtusissima, lobulo subaequilongo, laxe implicato, late lineari, haud soluto, angulo apiculato. Perianthia (vetusta subdeleta) clavata, 5-plicata. Androeceia lateralia, spicata, bracteis 3-4-jugis, diandris.

On dead branches of *Rosa rubiginosa* in shade of manuka, ca. 1000 ft., near Atiamuri, North Island, leg. K. W. Allison, 25.VI.31 (n. 102).

A very distinct species by reason of the cucullate concave leaf-apex, the very large water-sac and the long corner spine of the lobulus.

Physocolea Hodgsoniae Herz. n.sp. *

Dioica videtur (δ haud visa); exigua, omnium gentis minima, subhyalina, hepaticola. Caulis nec 4 mm. longus, brevissime ramulosus, repens. Folia contigua vel parum tegentia, sub angulo 45° patula, parum concava, apice saepius deversa, 0, 2 mm. longa, 0, 16 mm. lata, ovato-triangularia, basi antica truncata, marginibus ceterum arcuatis, optime papilloso-denticulatis, apice acuto; cellulae tenerrimae, regulariter hexagonae, diametro ca. $8-10\ \mu$, antice alte papillatae; lobulus maximus, $\frac{3}{4}$ folii longitudinem aequans, subglobosus, saccatus, margine supero emarginato, in medio valide dentato, dente lanceolato, e cellulis laevibus exstructo, angulo ipso obtuso, saepius inflexo abscondito, carina valde arcuata, dense alteque papillata, in folii marginem stricte excurrente (lobulus rudimentarius laevissimus, angulo longe hamato); stylus nullus. Folia floralia caulinis vix majora, lobulo aequimagno, haud saccato, conchaeformi-24 mm. crassum, subgloboso-ovoideum, inflatum, obtuse pentagonum, implicato, ceterum simillima. Perianthium 0, 25 mm. longum, 0, 24 mm. crassum, subgloboso-ovoideum, inflatum, obtuse pentagonum, in sicco 5-plicatum, dense papillosum, rostrum brevi, lato.

In bush near Wairoa, epiphytic on *Radula marginata* and *Plagiochila* spec., leg. E. A. Hodgson, I.31 (n. 56).

This very pretty species appears to resemble very closely the Australian *Aphanolejeunea mamillata* Angst., judging by the description of that plant, but it is amply distinct in the perianth.

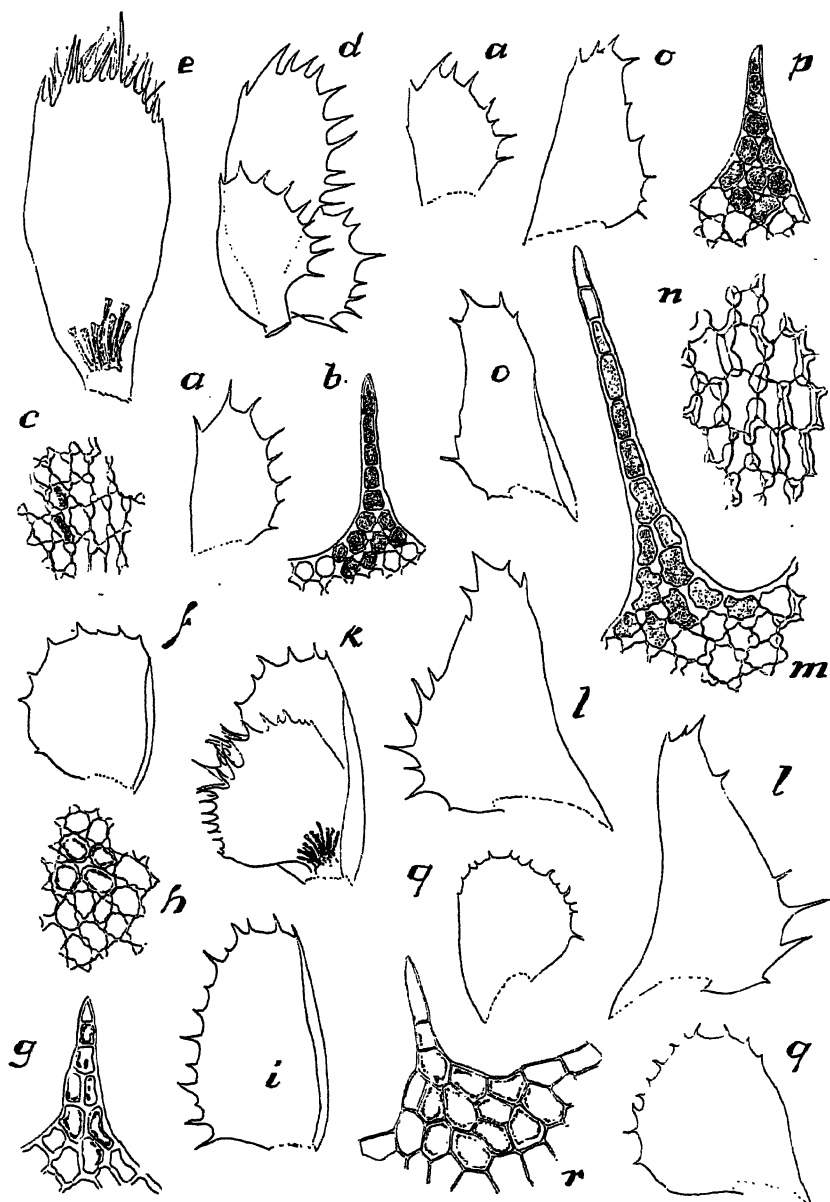


PLATE 3.—a-e. *Plagiochila lonchoscypha* Herz. n.sp. a, folia caulina $\times 21$; b, spina marginalis $\times 159$; c, cellulae basales $\times 159$; d, involucrem $\times 21$; e, perianthium $\times 21$.

f-k. *Plagiochila subquadrata* Herz. n.sp. f, folia caulina inf. $\times 12$; g, spina marginalis $\times 159$; h, cellulae basales fol. $\times 159$; i, folium florale $\times 12$.

l-n. *Plagiochila calcarata* Herz. n.sp. l, 2 folia caulina $\times 12$; m, spina marginalis inferior $\times 159$; n, cellulae basales $\times 159$.

o-p. *Plagiochila calcarata* var. minor. o, 2 folia caulina $\times 12$; p, spina marginalis $\times 159$.

q-r. *Plagiochila limpida* Herz. n.sp. q, 2 folia caulina $\times 12$; r, spina marginalis $\times 159$.

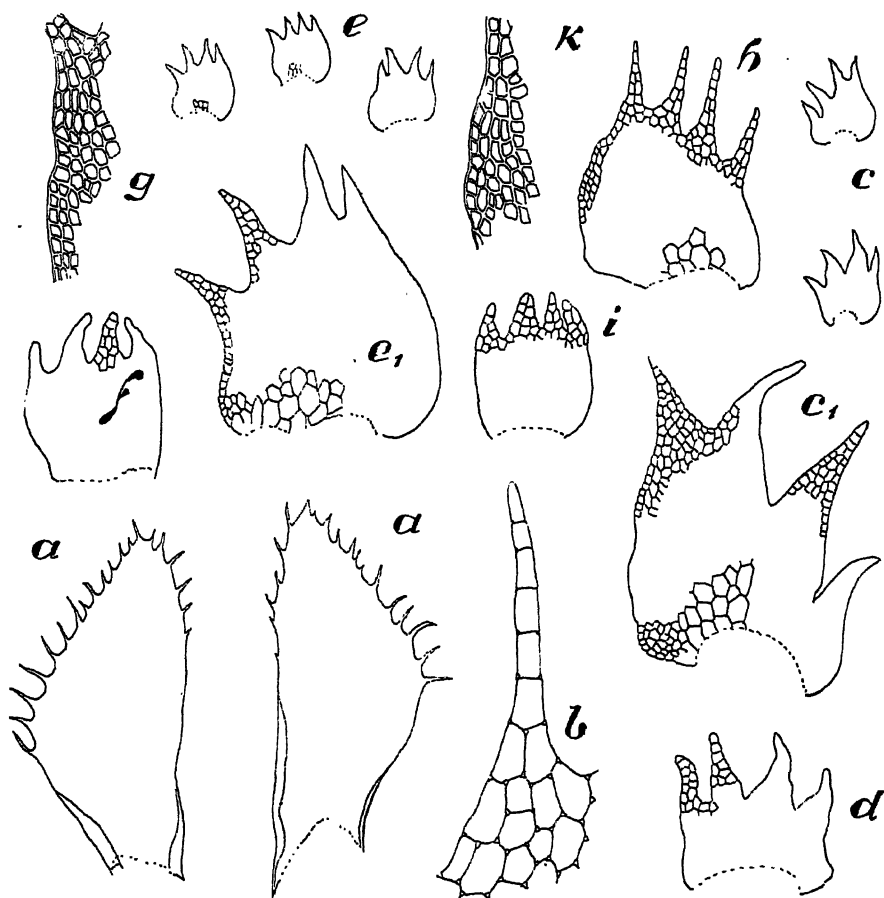


PLATE 4.—*a-b*, *Plagiochila elegantissima* Herz. n.sp. *a*, 2 folia caulina $\times 12$; *b*, spina marginalis $\times 159$.

c-d, *Lepidozia breviloba* St. (n. 68). *c*, folia caulina $\times 21$ (*c* $\times 87$); *d*, amphigastrium caulinum $\times 87$.

e-g, *Lepidozia brevisfolia* St. (n. 207). *e*, folia caulina $\times 21$ (*e* $\times 87$); *f*, amphigastrium caulinum $\times 87$; *g*, cellulae marginis $\times 159$.

h-k, *Lepidozia parviterea* St. (original). *h*, folium caulinum $\times 87$; *i*, amphigastrium caulinum $\times 87$; *k*, cellulae marginalis $\times 159$.

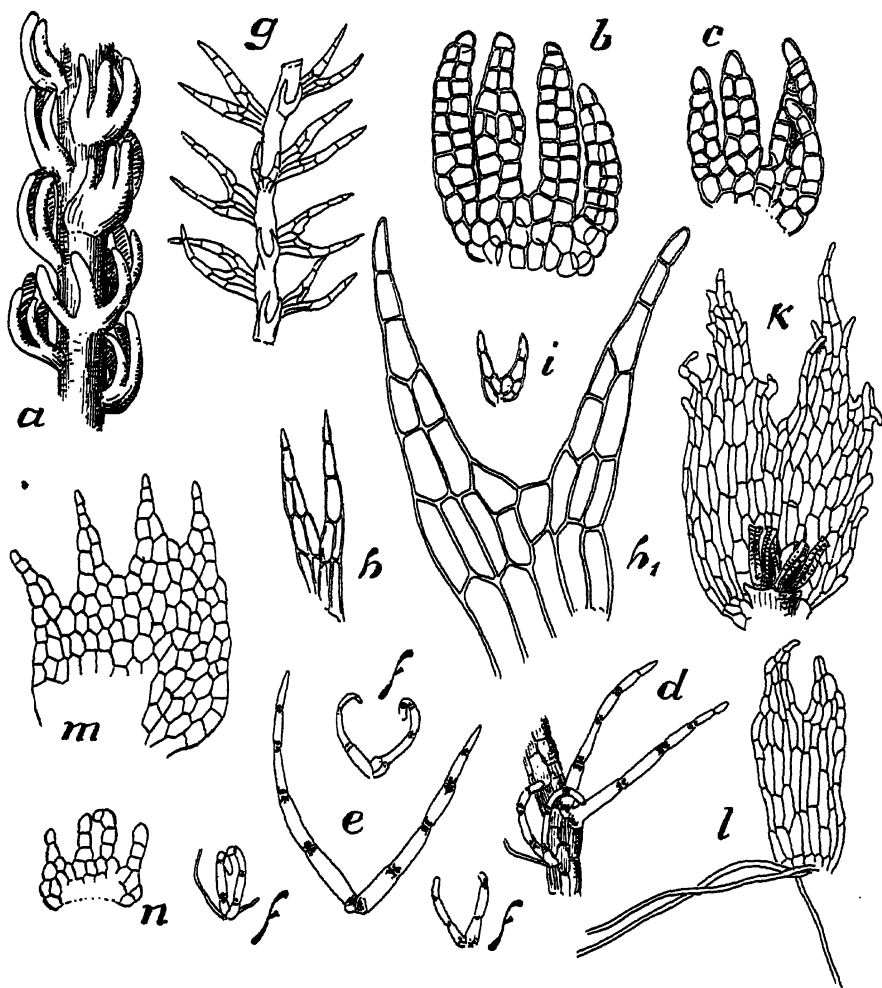


PLATE 5.—a-c, *Lepidozia Allisonii* Herz. n.sp. a, caulis cum foliis $\times 87$; b, folium caulinum $\times 150$; c, amphigastrium caulinum $\times 150$.

d-f, *Lepidozia bisetula* Herz. n.sp. d, caulis cum foliis et amphigastrio $\times 150$; e, folium caulinum $\times 150$; f, 3 amphigastria caulina $\times 150$.

g-l, *Lepidozia cavernarum* Herz. n.sp. g, caulis cum foliis et amphigastriis $\times 45$; h, folium caulinum $\times 87$ (h $\times 159$); i, amphigastrium caulinum $\times 87$; j, folium florale $\times 87$; k, amphigastrium florale $\times 87$.

m-n, *Lepidozia digitata* Herz. n.sp. m, folium caulinum $\times 87$; n, amphigastrium caulinum $\times 87$.

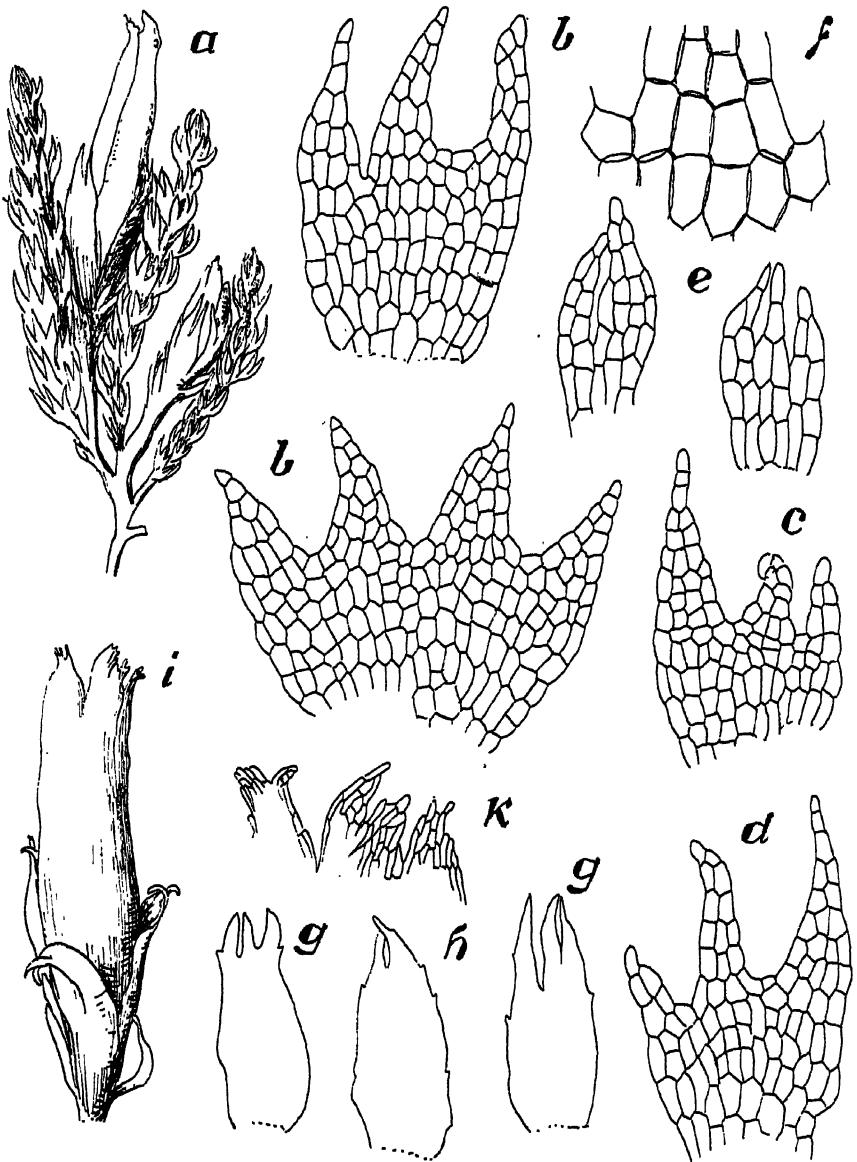


PLATE 6.—*Lepidozia leptodictyon* Herz. n.sp. *a*, planta $\times 12$; *b*, folia caulina $\times 87$; *c*, amphigastrium caullinum $\times 87$; *d*, folium rameum $\times 87$; *e*, amphigastrium rameum $\times 87$; *f*, cellulae folii $\times 159$; *g*, folia floralia $\times 21$; *h*, amphigastrium florale $\times 21$; *i*, perianthium $\times 21$; *j*, pars perianthii $\times 43$, *k*, oris perianthii $\times 43$.

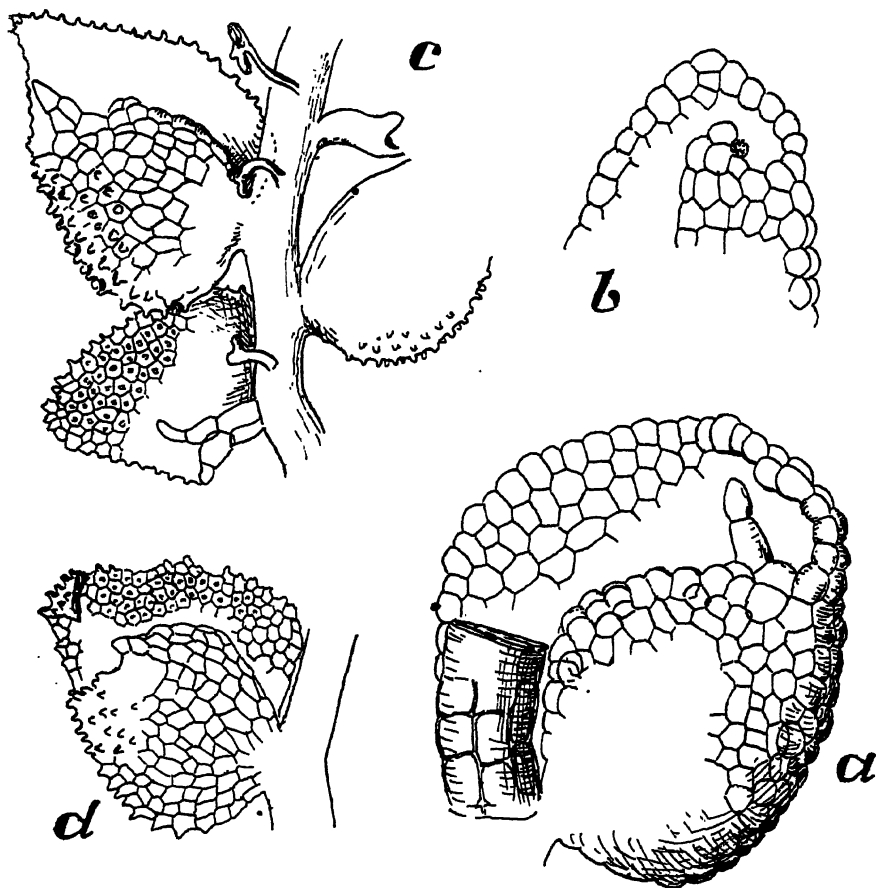


PLATE 7.—a-b, *Physocolea cucullifolia* Herz. n.sp. a, folium caulinum $\times 220$; b, apex folii floralis cum lobulo $\times 220$.

c-d, *Physocolea Hodgsoniae* Herz. n.sp. c, pars caulis cum foliis a ventre $\times 220$; d, folium caulinum $\times 220$.

The numbers of the magnifications of the figures are approximate, having been reduced in accordance with the reduction of the plates.—E. A. H.

A Brief Note on the Spinal Nerves of the Red Cod (*Physiculus bachus*).

By W. T. G. JOHNSTON.

[Read before the Wellington Philosophical Society, August 25, 1937; received by the Editor, September 15, 1937; issued separately, June, 1938.]

WHILE engaged in dissecting Red Cod in the laboratory, I observed a peculiarity in the origin and branching of the spinal nerves which appears to be of interest. Some half-dozen cod were examined, and in each case the peculiarity of the origin of the spinal nerves was observed; but the branching of these nerves was followed out only in the one case. The nerves were dissected out from a segment lying about the middle of the body of the cod, approximately the third segment following that one in which lies the posterior end of the coelom. In no instance was any other type of origin observed.

As may be seen in the diagram both the dorsal and ventral roots are double, each root bifurcating immediately after leaving the cord. The half roots thus formed pass out of the vertebral column in opposite directions, one dorsad and one ventrad. I propose to call the two members of the dorsal root D.D. and D.V. (Dorsal Dorsad and Dorsal Ventrad) respectively, and the two members of the ventral root V.D. and V.V.

Each member of the dorsal root bears a ganglion which lies near the point where the root member emerges from the vertebral column. The dorsal member of the dorsal root, D.D., unites some distance beyond its ganglion with the dorsal member of the ventral root of the segment in front, which half-root I shall call V.D.1 to distinguish it from V.D., which passes back to join the dorsal half-root of the segment behind. The ventral member of the dorsal root, D.V., unites a short distance beyond its ganglion with the ventral member of the ventral root, V.V., of its own segment.

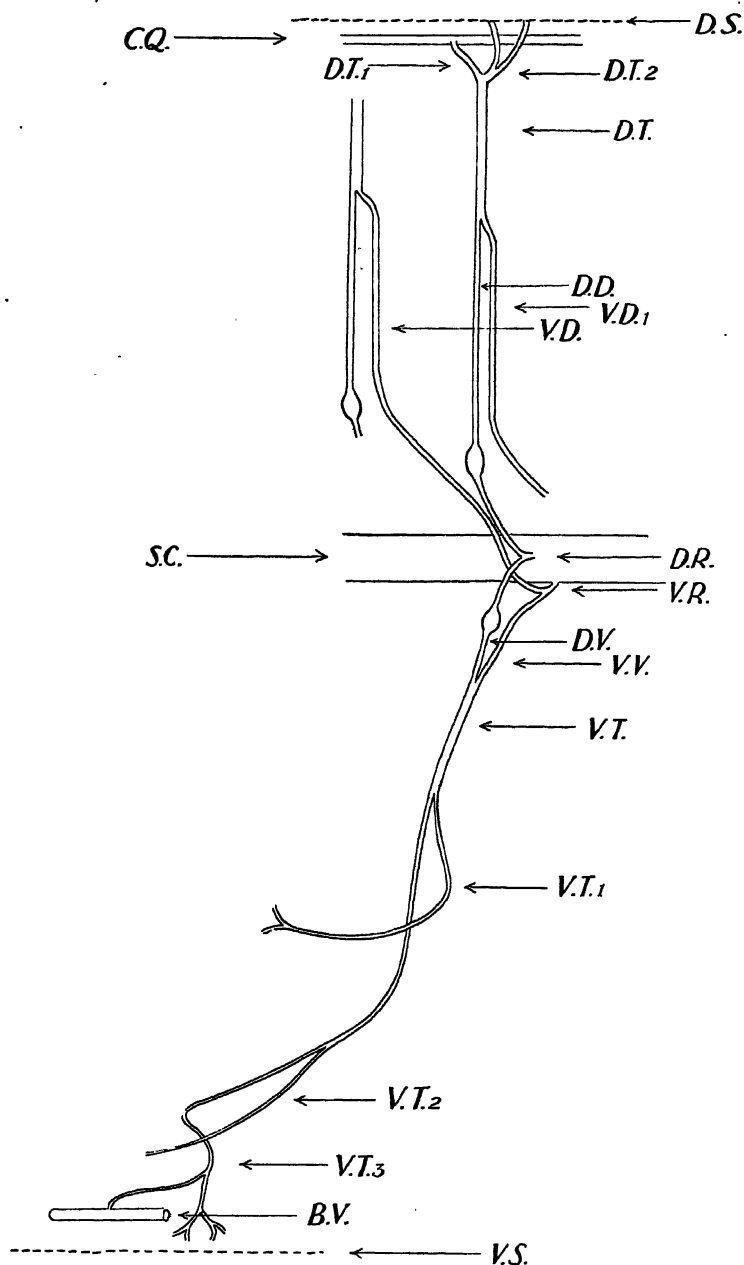
The effect is to give two spinal nerves instead of one. These I am referring to as the Dorsal Trunk and the Ventral Trunk.

The Ventral Trunk, soon after its origin, gives off a small branch, V.T.1, presumably motor, which supplies the muscular tissue of the corresponding myotome in the region of the horizontal septum.

The larger branch of the nerve passes outwards and backwards beneath the smaller branch and then dips downward toward the ventral fin. Before it nears the latter, however, it gives off another slender branch, V.T.2, which runs into the more ventral portion of the myotome. The remaining branch, V.T.3, ramifies diffusely just before reaching the skin next to the ventral fin, one of its branches apparently innervating a small blood vessel; this latter suggests that the nerve may contain sympathetic fibres, for which I have not sought. I have not traced any branches of this nerve to the skin.

The Dorsal Trunk runs straight up to the dorsal fin, where it breaks up into two or three branches. One of these branches, D.T.1, anastomoses with the Dorsal Fin branch of the Cutaneous Quinti of its side. It is possible that this anastomosing branch contains the motor fibres that have entered the trunk in V.D.1. The remaining branches, D.T.2, of the Dorsal Trunk disappear in the areolar tissue lying immediately beneath the skin to the side of the dorsal fin.

It is proper to say that in a dissection of a larger specimen previously made I had come to the conclusion that D.D. united with the ventral dorsad member, V.D., of its own segment and not with V.D.1 (that of the segment in front).



EXPLANATION OF LETTERING.

B.V. = blood vessel; C.Q. = dorsal fin branch of cutaneous quinti; D.R. = dorsal root; D.S. = skin of back; D.T. = dorsal trunk; S.C. = spinal cord
 V.R. = ventral root; V.S. = skin of belly; V.T. = ventral trunk.
 For other lettering see text.

To face page 48.

Notes on the Breeding Habits and the Early Development of *Dolichoglossus otagoensis* Benham.

By H. B. KIRK, Victoria University College, Wellington.

[Read before the Wellington Philosophical Society, November 24, 1937; received by the Editor, December 22, 1937; issued separately, June, 1938.]

Dolichoglossus otagoensis is found in considerable numbers at several points on the coast in the neighbourhood of Wellington. The worm never burrows in sand but lives among closely-growing seaweed or in crevices on the under side of stones. It often occurs in sheltered rock-pools in which there is an abundance of coralline seaweeds. These masses of coralline form a veritable nursery and home for many forms of life, and there is an abundance of minute organisms suitable as food for those animals that, like *Dolichoglossus*, capture their food by means of ciliary action.

Breeding begins about the middle of July and extends to about the middle of August. It has, so far as I have observed, no connection with the phase of the moon. A female worm about to breed seeks a sheltered crevice or a space among the bases of the seaweed stalks and there surrounds herself with a cocoon of sticky mucus, which later becomes tough and stringy, and sand grains and other particles may adhere to it. In most cases the cocoon completely conceals the worm, forming a tunnel open at both ends. Whether fertilisation takes place before the spinning of the cocoon I am not sure. The sperms of the male are freed from the gonad in rounded spermatophoric masses, which roll along slowly. I once found such a mass within a cocoon in which was a female with early embryos, but the sperms of the mass were not motile and could not be induced to display any activity. I never have found a female within a cocoon with eggs that had not at least begun segmentation.

Within the cocoon, the female rubs off the embryos, and cocoons may be found from which the worm has withdrawn leaving a double row of embryos that have not yet completed the first cleavage. This, however, is not an ordinary occurrence. More often it happens that the embryos are rubbed off later, and with them a considerable part of the gonadial ridges. In some cases the worm remains within the cocoon in this mutilated condition. More often it withdraws: sometimes it breaks across and the two portions withdraw. When this happens the anterior portion remains active for some time and undergoes regeneration, although I cannot say whether this ever is complete, but I believe it is. I have not been able to keep the animals alive long enough to be sure. The portions that have been thrown off remain within the cocoon, with the embryos more or less embedded in them. They lose brightness of colour, become very brittle and presently fall to pieces at a touch. It is extraordinary that they do not seem to support swarms of putrefactive organisms.

A very striking result of the manner of shedding the embryos that has just been referred to is that you often find in a cocoon a double line of embryos from six to thirteen in each line, all in approximately the same stage of development.

External Features of Development. Entry of the sperm has not been observed. The fertilised egg is spherical and is surrounded by a perfectly transparent egg capsule, which comes to stand away from the egg as in the case of the fertilised egg of many echinoderms. The first two cleavages are meridional, and the third is slightly nearer to the animal than to the vegetal pole. Cleavage goes on as regularly as in *Amphioxus* in most cases, and results in a spherical blastula. The difference in size between megameres and micromeres is noticeable, but not more so than in the species described by Bateson (*Q.J.M.S.*, xiv, Apl. 1884). Indeed, Bateson's figures of the blastula might almost apply to this animal. The most noticeable differences are that there is no special "transverse" band of cilia as the blastula begins to invaginate, and that the antero-posterior flattening of the embryo at this stage is here much less marked. As invagination advances ciliation is observable, the cilia developing uniformly over the whole surface. Invagination is perfectly regular. As the blastopore becomes smaller it begins to lose its circular outline and to become flattened from side to side. There is even a suggestion that it will close in the middle of its length, leaving the two ends open. This, however, does not happen, and closure is complete. As the blastopore closes ciliary action becomes more pronounced. The embryo becomes oval and slight movements of contraction are observable.

So far the embryo has remained within the egg capsule, but this has gradually become thinner and at about this stage the embryo escapes. There now begin two changes that alter the shape of the embryo considerably. The first is a slight dorso-ventral flattening, the second a narrowing at the anterior end, the end farthest from the position formerly occupied by the blastopore. The two collar grooves appear in their order, but before the second groove can be distinguished the longitudinal groove on the proboscis, that is such a marked feature of the adult, makes its appearance. It is for some time well marked on both dorsal and ventral surfaces. Before the collar is completely marked off there appears on its dorsal surface a shallow medullary groove, which later closes. Mouth and anus develop at about this time and the animal glides slowly about by means of its cilia, looking much like a very sluggish planarian. Its length is not twice its breadth, and the part that will form the proboscis is longer than the part that will form the body.

It has been stated that there is no post-oral band of cilia. Neither is there an apical tuft, although there is a loose group of nerve cells seen on longitudinal section, just below the ectoderm at the apex.

It very frequently happens that within the egg capsule there is a body much smaller than the embryo, that grows and segments for some time. In one case this was observed to have reached a size nearly half that of the embryo itself. I could not determine that this was the result of detachment of a blastomere, and, as it may be seen before what seems to be the first cleavage is completed, it probably is one of the polar bodies. It may persist until the gastrula stage is completed. Ultimately it breaks down and disappears.

By C. R. LAWS, D.Sc., Auckland.

THE Neozelanian Eulimellids fall into two divisions based on features of embryo. The new genus-name *Terelimella* is for slender forms with a single-whorled, very exsert embryo having a large, lateral, excentric nucleus, as well as certain other shell characters that are distinctive. *Eulimella* accommodates those forms with a typically smaller, closely coiled apex, having its lateral nucleus small and central.

KEY TO EULIMELLID GENERA.

Protoconch very exsert, of one turn, lateral nucleus large and ex-	
centric; shell attenuate and usually needle-like	<i>Terelimella</i>
Protoconch not strongly exsert, of several turns, low helicoid, lateral	
nucleus small and central; other characters typical of <i>Eulimella</i> . .	<i>Eulimella</i>

[illegible]

Genus EULIMELLA Jeffreys.

1847. *Ann. Mag. Nat. Hist.*, vol. 19, p. 311.Type: *Eulima macandrewi* Forbes.

Iredale (*Nautilus*, vol. 24, pp. 52-58; 1910: and again, *Trans. N.Z. Inst.*, vol. 47, p. 461; 1915) has shown that the reference given by Dall and Bartsch, and copied by Suter, is wrong, and that the earliest introduction of the genus-name *Eulimella* was by Jeffreys in the *Ann. Mag. Nat. Hist.*, 1847, for *Eulima macandrewi* Forbes.

Eulimella is not to be regarded as a subgenus of *Pyramidella*, for, as Iredale has pointed out (*Trans. N.Z. Inst.*, vol. 47, p. 461; 1915) the formation of the aperture clearly separates it out, whilst it has a wider geographical range than *Pyramidella*. The same writer (*P.M.S.*, vol. 2, pt. 6, 338; 1915) has drawn attention to the fact that Dall and Bartsch in making *Eulimella* a subgenus of *Pyramidella* have written "Columella folds two." The author (Forbes) wrote "Columella not plicated, straight, or nearly so," and this, Iredale states, appears to have been the opinion of every writer, save Dall and Bartsch, that he has consulted.

In *Eulimella* the protoconch is heterostrophic, helicoid, the shell tall and of many whorls, and the aperture generally more or less subquadrate and with no plait, or only a very low, feeble swelling set on a straight columella. The shell is usually of rather solid build, has no axial ornament other than growth-striae or occasionally low, indistinct growth-plications, and is either spirally unsculptured or has only microscopic striae present.

KEY TO SPECIES OF EULIMELLA.

Shell not less than 4.0 mm. high.

Outlines of shell straight, not convex.

Shell large, very considerably attenuate.

Whorls high, flattish; suture just below periphery;
aperture ovate

alpha

Shell not so large and not considerably attenuate.

Whorls not regularly increasing.

Later whorls increasing more rapidly than early
ones; suture but little impressed; whorls lightly
convex; columellar fold obsolete; spiral striae
present

levilirata

Whorls regularly increasing.

Suture well cut in; whorls flattish over centre;
shell thick and solid; a low, wide fold on colu-
mella

deplexa

Suture not cut in; whorls lightly convex; shell
not solid for its size; no fold on columella ..

beta

Outlines of shell not straight, convex, especially over earlier whorls

Whorls concave, swollen above; spire somewhat gradate

mestayerae

Whorls not concave, not swollen above, and spire not gradate.

Suture strongly cut in, almost channelled; aperture
subquadrate; whorls convex

limbata

Suture not much incised; aperture subovate; whorls
not so convex

larga

Shell smaller, less than 4.0 mm. high.

Whorls flat.

Protoconch emergent, rather sharp at summit; suture not distinct; periphery sub-angled *waihoraensis*

Protoconch more depressed, bluntly rounded over summit; suture more incised; periphery convex; whorls lightly and broadly concave *coen*

Whorls not flat, but convex.

Whorls lightly convex; suture moderately incised; whorls many; apex sharp; aperture rather subquadrate; shell slender *coena*

Whorls strongly convex; suture considerably incised; whorls few; apex not sharp; aperture ovate; shell stouter and with axial plications *media*

Note.—*E. awamoensis* has not been placed in the above key, as no specimen has been available for examination.

***Eulimella alpha* n.sp. (Fig. 6).**

Shell large, exceedingly attenuate, outlines straight. Post-nuclear whorls 7 remaining (earlier ones decollated), flat to very lightly convex; suture but little impressed. Protoconch missing. Sculpture absent, except for growth-striae, which are sinuous. Body-whorl flattish above, well rounded over periphery, base convex; aperture subovate, angled behind, rounded in front; columella vertical, faintly arcuate, a very low swelling high up at insertion; inner lip callused; basal lip narrowly rounded; outer lip broken.

Height (estimated), 9.0 mm.; width, 1.5 mm.

Locality: Hampden (Bortonian).

Type in Auckland Museum (ex writer's collection).

The large size, very attenuate habit and high whorls between sutures, readily mark this species off from other Neozelanic *Eulimella*.

***Eulimella beta* n.sp. (Fig. 15).**

Shell of moderate size, elongate-conic, outlines straight. Post-nuclear whorls 5½ remaining (earlier ones decollated), lightly convex and a little bulging below; suture only a little incised. Protoconch missing. Sculpture absent, and growth-lines not evident. Body-whorl, flattish above, strongly convex over periphery, lightly convex on base; aperture broadly ovate, angled behind, widely rounded in front; columella short, stout, straight, vertical and with no plait; inner lip not callused; basal lip broadly rounded; outer lip straight.

Height (estimated), 5.8 mm.; width, 1.45 mm.

Locality: Hampden (Bortonian).

Type in Auckland Museum (ex writer's collection).

A smaller and stouter species than *alpha* with whorls a little more convex and much less high, and aperture shorter and broader.

***Eulimella levilirata* Murdoch and Suter. (Fig. 10).**

1906. *Eulimella levilirata* Murdoch and Suter, *Trans. N.Z. Inst.*, vol. 38, p. 296, pl. 25, fig. 38.

1906. *Pyramidella (Syrnola) tenuiplicata* Murdoch and Suter, *Trans. N.Z. Inst.*, vol. 38, p. 296, pl. 25, fig. 39; Suter, *Man. N.Z. Moll.*, p. 332, pl. 16, fig. 12, 1913.

1913. *Pyramidella (Eulimella) levilirata* Murdoch and Suter. Suter, *Man. N.Z. Moll.*, p. 329, pl. 16, fig. 8 (Atlas).

The figure in the Manual is unsatisfactory, for it shows the whorls too convex and makes the shell too slender. Actually the later whorls of the holotype increase more rapidly than the earlier few, giving a pencil-point aspect to the summit. The embryo is large and heavy, and its lateral nucleus is small and entirely free of first adult volution. The suture should not be described as "well" impressed; it is very little cut in. This species is rather variable in width of spire. In some specimens only the first two adult whorls are narrow, disproportionate increase in width beginning early, whilst in others there are three or four narrow whorls before rapid increase begins. Again, in some shells that otherwise cannot be distinguished from the type, the outline is practically straight and the increase in whorl-width proportionate throughout. Juvenile specimens often appear very slender and narrow, and from them one may be apt to estimate inaccurately the character of the adult outline, and possibly regard them as a distinct species, if the typical nature of the growth of whorls is overlooked.

Height, 4.2 mm.; width, 1.4 mm. (holotype).

Localities: Off Great Barrier Island, in 110 fathoms (type); Orua Bay, Manukau Harbour; Hen and Chickens Islands, in 25 fathoms; Cuvier Island, in 38 fathoms; off Otago Heads in 70 fathoms; off Oamaru, in 50 fathoms; Castlecliff, Wanganui (Castlecliffian); Nukumarū (Nukumaruān); Takapau.

Type in Dominion Museum, Wellington.

Suter's dimensions are frequently inaccurate. In the Manual he gives the height of the holotype as 6.0 mm.

Pyramidella (*Syrnola*) *tenuiplicata* Murdoch and Suter is to be included in the synonymy of this species. Finlay (*Trans. N.Z. Inst.*, vol. 57, p. 405; 1926) suggested that *tenuiplicata* be neglected in the meantime, as the type is a decorticated apical fragment, and not sufficient to render the species determinable. Examination of the specimen, however, shows it to be a *Eulimella*, for there is no plait. The apex and early whorls are inseparable from those of *E. levilirata* Murdoch and Suter, from the same locality, and one has no hesitation in uniting these two forms. Corrosion around the sutures of *tenuiplicata* has altered the true appearance of the shell, but, when this is allowed for, the specimen is seen without doubt to be nothing but a juvenile *levilirata*. These two species are described by Murdoch and Suter on the same page, but *levilirata* has place preference, so that the name *tenuiplicata* must be suppressed.

***Eulimella deplexa* Hutton. (Fig. 2).**

1884. *Eulimella deplexa* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 318.

1893. *Eulimella deplexa* Hutton, *Macleay Mem. Vol.*, Plioc. Moll., p. 56, pl. 7, fig. 45.

1915. *Pyramidella* (*Eulimella*) *deplexa* Hutton. Suter, *N.Z.G.S. Pal. Bull.*, no. 3, p. 14.

Hutton's type is not an adult shell. Specimens of *deplexa* from Nukumaru and from the Pliocene beds of Hawkes Bay show that the species grows to a much larger size, and that there are microscopic striae between sutures as well as on the base.

Height, 3.0 mm.; width, 1.0 mm. (holotype). Corresponding dimensions of a Nukumaru shell: 4.1 mm.; 1.2 mm.

Localities: Wanganui, Pliocene (type); Nukumaru (Nukumaruan); Maraekakaho, Kereru, Hawkes Bay (Nukumaruan).

Type in Canterbury Museum, Christchurch.

Eulimella mestayerae (Marwick). (Fig. 4).

1931. *Syrnola mestayerae* Marwick, *N.Z.G.S. Pal. Bull.*, no. 13, p. 105, fig. 193.

The surface of the holotype is corroded so that any minute sculpture may have been obliterated. The shell is partly embedded in matrix, and the features of the heterostrophic embryo are therefore indeterminate. The concave, staged whorls are distinctive.

Height, 6.6 mm.; width, 2.1 mm. (holotype).

Localities: N.Z.G.S. locs. 1295 (type), and 1319, Gisborne District, Ihungia Series (Hutchinsonian).

Type in collection of N.Z. Geological Survey, Wellington.

The figure is a reproduction of Dr Marwick's illustration.

Eulimella limbata Suter. (Fig. 8).

1907. *Pyramidella (Eulimella) limbata* Suter, *Trans. N.Z. Inst.*, vol. 40, p. 362, pl. 28, fig. 5.

1913. *Pyramidella (Eulimella) limbata* Suter, *Man. N.Z. Moll.*, p. 330, pl. 16, fig. 9 (Atlas).

The type is a poor specimen with the apex decollated and the surface rubbed smooth, so that it is impossible to tell whether fine sculpture was originally present. Good specimens, however, have excessively fine microscopic striae between sutures and on base.

Suter's drawing is not a good representation of his type. It shows the whorls too flat and does not convey the convex outline over the summit-whorls, which is a constant specific character.

Height: 4.5 mm.; width, 1.5 mm. (holotype).

Localities: Bay of Islands (type); Orua Bay, Manukau Harbour; Takapuna Beach, Auckland; Dunedin Harbour; off Otago Heads, in 40 fathoms (one shell, which may have been washed down).

Type in Wanganui Museum.

Eulimella larga n.sp. (Fig. 11).

Shell of moderate size, elongate-conic, outlines convex. Post-nuclear whorls $8\frac{1}{2}$ in number, earlier ones flat, later ones flat above and a little bulging and overhanging below; suture not greatly impressed. Protoconch heterostrophic, of about 2 volutions; very low helicoid lateral nucleus, small, central. Sculpture absent, but some indefinite spiral striae on last whorl of one specimen. Body-whorl flattish above, periphery strongly convex (sub-angled in immature shells), base lightly convex; aperture subovate, angled behind, narrowly rounded in front and rather drawn round to axis of shell; columella straight, about vertical, a low, almost obsolete fold high up near insertion; parieto-columellar junction differentiated; inner lip not callused; basal lip narrowly rounded and drawn down; outer lip about straight.

Height, 5.5 mm.; width, 1.5 mm. (holotype).

Localities: Rifle Butts (type); shell-bed, Target Gully; Awamoa Creek; Pukeuri; Ardgowan shell-bed. All the above are Awamoan horizons around Oamaru. Also Chatton, near Gore, Southland (Ootaran); and Mt. Harris and Sutherlands (Awamoan horizons in South Canterbury).

Type in Auckland Museum (ex writer's collection).

Has the convex outline of *limbata*, but not the deep, almost channelled suture of that species. Differs also from *limbata* in apertural shape and in shape of whorl.

Eulimella waihoraensis (Marwick). (Fig. 9).

1931. *Syrnola waihoraensis* Marwick, *N.Z.G.S. Pal. Bull.*, no. 13, p. 106, fig. 195.

The heterostrophic embryo is coiled in a very low helicoid spiral, the lateral nucleus small and central. There is no plait.

Height, 3.8 mm.; width, 1.1 mm. (holotype).

Localities: N.Z.G.S. loc. 1293, Gisborne District, Ihungia Series (Hutchinsonian); Clifden, Southland, band 6A (Hutchinsonian).

Type in collection of N.Z. Geological Survey, Wellington.

Eulimella coxi n.sp. (Fig. 1).

Shell small, elongate-conic, outlines very faintly convex. Post-nuclear whorl $7\frac{1}{2}$ in number, flat but with a very faint, wide sulcate zone around centre; suture weak, very little impressed. Protoconch heterostrophic, as a whole more immersed than is usual; the lateral nucleus small, central and about one-half sunken in succeeding adult volution. Spiral sculpture is present in the form of microscopic striations. Body-whorl faintly concave above, expanded and sharply convex at periphery, lightly convex on base; aperture subrhomboidal, angled behind, rounded in front; columella straight, vertical, a very light swelling seen inside only when outer lip is broken back; inner lip lightly callused; basal lip rounded; outer lip straight.

Height: 3.7 mm.; width, 1.0 mm. (holotype).

Locality: White Rock River, South Canterbury (Awamoan).

Type in Auckland Museum (ex writer's collection).

This species stands closest to *waihoraensis* (Marwick), which, however, has more emergent and narrower protoconch, straight outline with much narrower spire over early adult whorls, and no light concavity on whorl.

Named in honour of Mr L. R. Cox, M.A., of the British Museum of Natural History, London.

Eulimella coena Webster. (Fig. 7).

1904. *Eulimella coena* Webster, *Trans. N.Z. Inst.*, vol. 37, p. 279, pl. 10, fig. 11.

1913. *Pyramidella (Eulimella) coena* Webster. Suter, *Man. N.Z. Moll.*, p. 329, pl. 16, fig. 7 (Atlas).

The holotype is an immature shell. Suter's figure is that of a mis-shapen shell that cannot be identified with the type. Webster's

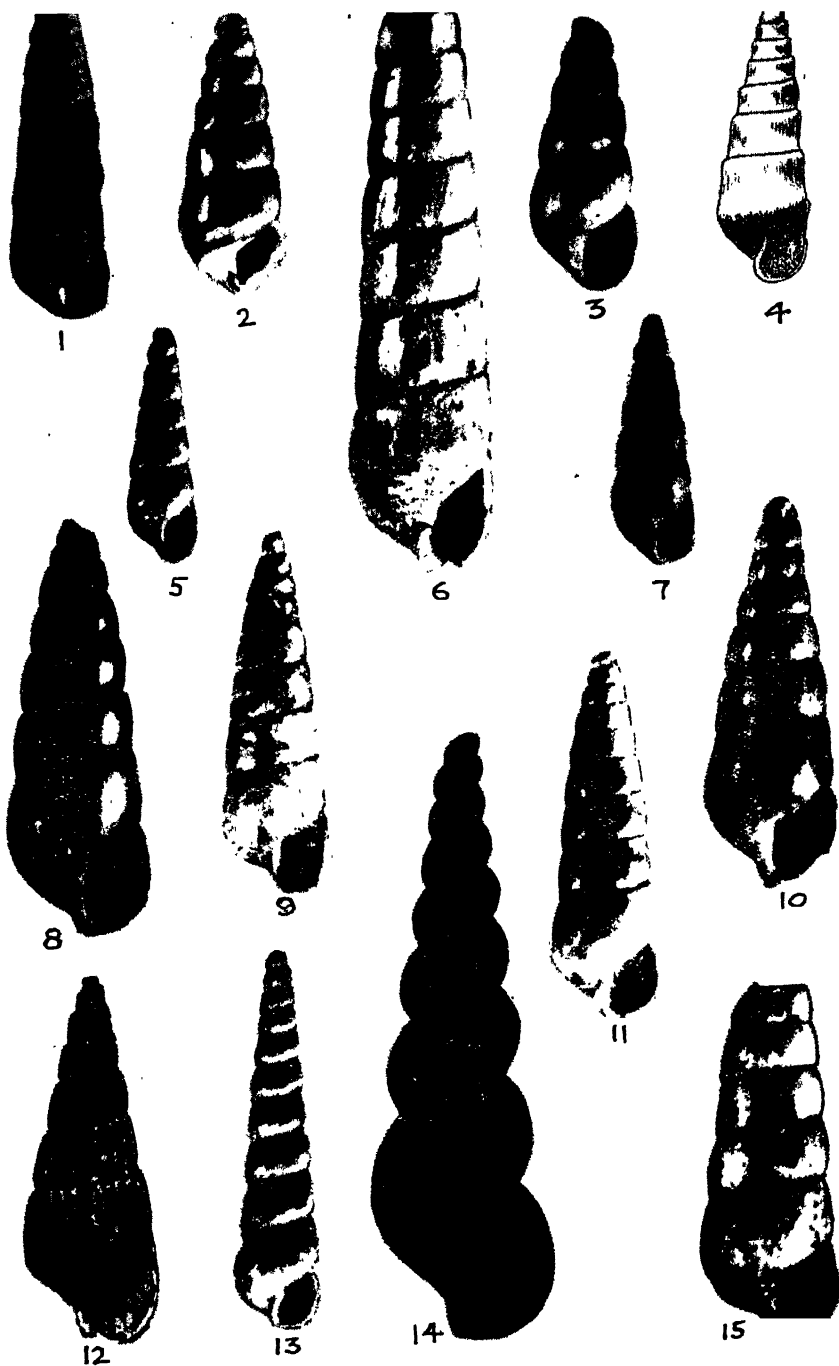


FIG. 1—*Eulimella cori* n.sp.; holotype. $\times 13$. FIG. 2—*Eulimella deplewa* Hutton; holotype. $\times 13$. FIG. 3—*Eulimella media* Hutton; holotype. $\times 13$. FIG. 4—*Eulimella mestayerae* (Marwick); holotype. FIG. 5—*Terclimella hutchinsoniana* n.gen. n.sp.; holotype. $\times 13$. FIG. 6—*Eulimella alpha* n.sp.; holotype. $\times 13$. FIG. 7—*Eulimella coena* Webster; holotype. $\times 13$. FIG. 8—*Eulimella limbata* Suter; holotype. $\times 13$. FIG. 9—*Eulimella waihoraensis* (Marwick); holotype. $\times 13$. FIG. 10—*Eulimella levitirata* Murdoch and Suter; holotype. $\times 13$. FIG. 11—*Eulimella larga* n.sp.; holotype. $\times 9.4$. FIG. 12—*Eulimella awamoensis* Marshall and Murdoch; holotype. $\times 7.1$. FIG. 13—*Terclimella ototurana* n.gen. n.sp.; holo-

original figure is a much more accurate one, though it does not represent the shell as sufficiently slender, and shows the suture with a margin, which actually is not present.

The type is worn and the surface is badly rubbed. Good topotypes show microscopic striae and scratches between sutures and on base.

Height, 2.7 mm.; width, 0.9 mm. (holotype).

Locality: Takapuna, Auckland.

Type in War Memorial Museum, Auckland.

***Eulimella media* Hutton. (Fig. 3).**

1884. *Eulima media* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 318, pl. 18, fig. 13.

1893. *Eulima* (?) *media* Hutton, *Maclacay Mem. Vol.*; *Plioc. Moll.*, p. 56, pl. 7, fig. 43.

1915. *Pyramidella (Eulimella) media* (Hutton). Suter, *N.Z.G.S. Pal. Bull.*, no. 3, p. 15.

The type and an immature paratype are the only specimens the writer has seen. The species is quite distinctive. It has a large blunt embryo, strongly convex whorls, and deep suture. It is unusual in the possession of low axial plications, especially visible towards the summits of the whorls. Microscopic striae are present between sutures and on base.

Suter (*loc. cit.*, p. 15) stated that this species stands very close to *levilirata* Murdoch and Suter. Actually it stands no nearer to *levilirata* than to any of the other Neozelanic species, and it does not seem to come particularly close to any of them.

Height, 3.0 mm.; width, 1.0 mm. (holotype).

Locality: Wanganui (Castlecliffian).

Type in Canterbury Museum, Christchurch.

***Eulimella awamoensis* Marshall and Murdoch (Fig. 12.)**

1921. *Eulimella awamoensis* Marshall and Murdoch, *Trans. N.Z. Inst.*, vol. 53, p. 83, pl. 19, fig. 4.

No specimens have been studied during this revision. The holotype cannot at present be traced, and no *Eulimella* from Awamo and other Awamoan horizons correspond to Marshall and Murdoch's figure and description. The figure does not show the "channelled" sutures of the description. The presence of feeble axial riblets seems to be distinctive, as this has been found in no other species, save *media* Hutton, which is a very different style of shell, however.

Height, 7.0 mm.; width, 2.25 mm.

Locality: Awamo, Oamaru (Awamoan).

Marshall and Murdoch state that in general form their species is near *E. limbata*. This does not seem to be so, at least judging by their figure. *Limbata* has not the straight outline nor the sub-angulation of periphery, and the suture is different.

The figure is a reproduction of Marshall and Murdoch's illustration.

Genus *TERELIMELLA* n.gen.Type (o.d.): *Terelimella ototarana* n.sp.

The name *Terelimella* is for a compact little assemblage consisting of two mid-Tertiary fossils and two Recent species. Of the fossil species one is Ototaran in age and the other Hutchinsonian.

The general ensemble of shell features at once sets these species apart from other Eulimellids. The chief group-characters are the very exsert, erect protoconch of a single heterostrophic turn with large, excentric lateral nucleus; the acicular habit and distinct sutures.

KEY TO SPECIES OF *TERELIMELLA*.*

Shell small but not minute.

Shell extremely attenuate, needle-like; whorls lightly convex; weak plait present; protoconch not sharply rounded at summit

ototarana

Shell not so attenuate nor so needle-like; whorls flat above, bulging and overhanging below; no fold on columella; protoconch sharply rounded over summit

hutchinsoniana

Shell minute.

Whorls distinctly convex, evenly rounded; suture strongly cut in; apex small; columella straight

larouchi

***Terelimella ototarana* n.sp. (Fig. 13).**

Shell very small, slender and exceedingly attenuate, outlines straight. Post-nuclear whorls 9, similar in shape to those of *hutchinsoniana* n.sp., but not quite so flat above and the anterior bulge more prominent, so that whorls overhang suture more; suture a little more impressed. Protoconch very high, exsert, sharply convex at summit and of one volution; nucleus large, excentric, a little immersed. Sculpture of extremely faint, close microscopic striae and a fine incised line sub-margining suture of upper whorls of spire. Body-whorl strongly convex; aperture ovate, widely angled behind, rounded in front; columella set vertically arcuate, a low, rounded fold above giving it sinuosity, but in some specimens it is practically straight and the fold less obvious; parieto-columellar junction well differentiated; inner lip not callused; basal lip rounded; outer lip very lightly convex.

Height, 4.0 mm.; width, 0.8 mm. (holotype).

Locality: Chatton, near Gore, Southland (Ototaran).

Type in Auckland Museum (ex writer's collection).

The much more attenuate form, more bulging and overhanging whorls, and presence of low fold on the columella distinguish this species from *hutchinsoniana*.

***Terelimella hutchinsoniana* n.sp (Fig. 5):**

Shell very small, slender and considerably attenuate, outlines straight. Post-nuclear whorls 6 in number, flat above, descending obliquely exactly from suture, rapidly convex (or sub-angled) below overhanging suture; suture but little impressed. Protoconch hetero-

* *Eulimella aupouria* Powell, described since preparation of the manuscript of the present paper, is not included in the key.

strophic, high, exsert, sharply convex (not evenly rounded) at summit and of one volution; nucleus large, excentric, a little immersed. Sculpture absent, except for a faint microscopic incised line as a sub-margin to suture. Body-whorl flattish above, convex over periphery, lightly convex on base, which rapidly retreats to axis of shell; aperture ovate, angled behind, rather narrowly rounded in front; columella straight, vertical, its base a little expanded, no plait; parieto-columellar junction sub-angled and well differentiated; basal lip narrowly rounded; inner lip not callused; outer lip straight.

Height, 2.5 mm.; width, 0.75 mm. (holotype).

Locality: Clifden, Southland, band 6A (Hutchinsonian).

Type in Auckland Museum (ex writer's collection).

Terelimella larochei (Powell). (Fig. 14).

.930. *Eulimella larochei* Powell, *Trans. N.Z. Inst.*, vol. 61, p. 544, pl. 87, fig. 22.

This is a much smaller shell than either of its fossil relatives, and has the whorls more strongly and evenly convex and not bulging low down, slightly sinuous growth-striae, and less attenuate spire.

Height, 2.17 mm.; width, 0.54 mm. (holotype).

Localities: Mongonui Head, in 6–10 fathoms (type); Tryphena Bay, Great Barrier Island, in 5–6 fathoms; Awanui, in 12 fathoms; Castlecliff (Pliocene).

Type in collection of Mr A. W. B. Powell, Auckland.

The figure is a reproduction of Powell's illustration.

Terelimella aupouria (Powell).

1937. *Eulimella aupouria* Powell, *Discovery Reports*, vol. 15, p. 210, pl. 54, fig. 9.

This minute species was taken in 92 m. off Three Kings Islands.

Height, 2.25 mm.; width, 0.58 mm. (holotype).

Type in British Museum of Natural History, London.

Notocallista and Its Allies.

By J. MARWICK, N.Z. Geological Survey.

[Read before the Wellington Philosophical Society, October, 1936; received by the Editor, December 15, 1937; issued separately, June, 1938.]

THE affinities of the Venerid genus *Notocallista* Iredale, 1924, have been questioned by R. B. Stewart (1930, p. 242), who considered the group more closely allied to *Pitar* than to *Paradione*, under which the writer (Marwick, 1924, p. 591) had placed it as a sub-genus. At the same time, Stewart showed that *Paradione* had been unnecessarily proposed by Dall as a substitute for *Chionella* Cossmann, since the earlier *Chionella* Swainson was clearly a misspelling of *Cionella* Jeffreys. This criticism has prompted further study of the Australian and New Zealand members of the subfamily Pitarinæ with somewhat unexpected results, the *Notocallista*, as at present used, being found to consist of three distinct groups.

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For their generous loans and gifts of specimens and for information concerning works not available in Wellington the writer is greatly indebted to the following:—Mrs W. V. Ludbrook, Miss M. K. Mestayer, Dr R. S. Allan, Mr F. S. Colliver, Mr B. C. Cotton, Dr H. J. Finlay, Mr A. C. Frostick, Mr R. A. Keble, Dr W. R. B. Oliver, Mr A. W. B. Powell, Mr F. A. Singleton, and the Australian Museum.

Most of the new Australian species described below had already been noted in manuscript as distinct by Dr Finlay and Mr Singleton.

CRITERIA FOR CLASSIFYING THE PITARINÆ.

To separate his three chief genera of the Pitarinæ, *Callista*, *Amiantis*, and *Pitar*, Jukes-Browne (1913, p. 337) gave the following criteria as mainly to be relied on:

- (1) The existence in *Amiantis* and *Pitar* of a channel leading from the pit between the anterior laterals of the right valve below the anterior cardinal into the first interdental socket,
- (2) the position and shape of the left posterior cardinal,
- (3) the form and direction of the pallial sinus.

He further added that neither the characters of the external surface nor the bridge connexion of the anterior and posterior cardinals in the right valve are to be depended upon.

Such statements must be interpreted liberally, because small differences in the hinge may be much less significant than great differences in the sculpture. Indeed, the words "small" and "great" are themselves exceedingly loose terms when each is applied to a different character. Consequently, until a mathematical basis is accepted, it may not be possible to arrive at an accurate classification that is acceptable on all sides.

Further, to use any one criterion or set of criteria consistently is extremely difficult. As an example, take Jukes-Browne's (1913, p. 338) treatment of *Pitar* Römer. Of the genotype *V. tumens* Gmelin, he stated, "the left posterior cardinal resembles that of *Amiantis* in being confluent with the nymph along its whole course, and in this respect differs from most other species of *Pitaria*"; also the pallial sinus is "long, horizontal, linguiform and pointed at the anterior end like that of *Amiantis callosa* and *A. dione*." This suggests that many of the species or groups classed in *Pitar* by Jukes-Browne and contributing to his conception of the genus may not really belong there. The matter is further complicated by obscurity as to the characters of the genotype itself. H. v. W. Palmer's figure (1926, Pl. 1, fig. 5), reproduced from a photo, shows a deep groove separating the left posterior cardinal for most of its length from the nymph; also Cössmann and Peyrot's (1911, p. 372) line drawing shows a definite groove the full length of the tooth. Certainly in neither of the originals could it have resembled that of *Amiantis* in being "confluent with the nymph along its whole course."

N. M. Tegland's (1929, Pl. 21) reproductions of Römer's figures show a shell with a very deep escutcheon as also do Cössmann and Peyrot's figures, but the shell of Palmer's photographs has quite a shallow one. Obviously such an important genotype as *V. tumens* should be definitely fixed to a lectotype or neotype by someone with access to authoritative collections, and carefully detailed figures and descriptions made readily available.

Broadly speaking, the hinge is undoubtedly the best guide to Venerid classification, being generally the most conservative part of the shell; nevertheless elements of it vary to a certain extent, even within the one species.

As Jukes-Browne noted, the attitude of the left posterior cardinal in the different groups is important. In most of the Cretaceous species which have had their hinges clearly described or figured, e.g., *Callistina plana* (Sowby.) Europe and India, *Aphrodina tippiana* (Conr.) North America, and *Trigonocallista uzambiensis* (Woods) South Africa, this tooth is very long and well separated from the nymph. The writer's description and figure (Marwick, 1924, p. 595) of *Tikia wilckensi* (Woods) New Zealand is wrong. The left hinge has now been further cleared of matrix and shows a long, separated tooth (Pl. 10, fig. 7). Stoliczka's figures present some doubtful cases, but certainly, in the Upper Cretaceous, the dominant hinge had a long and separated left posterior cardinal.

In the rich Eocene faunas of the Paris Basin figured by Cössmann and Pissarro there are many species in the subfamily with a free left posterior cardinal, but others such as *Calpitarina* have it partly fused to the nymph and some such as *Microcallista* have it fused throughout. In the Miocene, most of the large shells have a fused left posterior cardinal and the position is much as in recent faunas. It seems fair to infer, then, that the free tooth is a primitive characteristic and the confluent tooth has developed from it. This conclusion is supported by the ontogeny of *multistriata*. Juvenile

shells have the cardinal well separated from the nymph. (See Pl. 10, figs. 1, 2.) The character appears to be connected in some way with the shape of the shell and differs to a certain degree in different individuals within the species.

Though, naturally, great differences in the strength of the sculpture exist between different groups and to a less extent within the groups, the kind of sculpture, concentric ridges and grooves tending to obsolesce, is really very constant throughout the subfamily.

An important character that has been rather neglected in classification is the manner of setting of the ligament. In some groups, e.g., *Notocallista* s. str. (Pl. 10, fig. 14), the ligament-walls are quite low and have rounded edges, so that the ligament and the nymphs are well exposed on the closed shell. In others, e.g., *Chionella* (Pl. 10, fig. 9), the ligament-walls are relatively high, so that the ligament and nymphs are deeply sunk and little exposed on the closed shell. A typical example of this kind of ligament is developed on *Lioconcha castrensis* (Linné). In some Pitarinæ, although the nymphs are not deeply sunk, the walls are high through being raised as a crest along the dorsal margin (Pl. 10, fig. 3). Dall described this feature in *Hysteroconcha*, and a less in-curved crest is developed as a specific feature in the Pliocene and Recent New Zealand *multistriata*. The narrow, low ridge on the posterior inner margin of the Pitarinæ forms a useful datum by which to judge the degree of immersion of the ligament.

Most if not all of the criteria of classification show a certain range of variability in the one species, even in specimens from the same locality; for example, the set of the hinge, the shape and size of the sinus, the relative sizes of the teeth, especially the right anterior and the left posterior cardinals; the amount that the right anterior cardinal deflects the groove leading back from the anterior lateral pit, the degree of separation of the pedal retractor from the anterior adductor, and the strength and persistence of the sculpture in the middle of the disc.

THE AFFINITIES OF NOTOCALLISTA.

Notocallista was introduced by Iredale (1924, p. 210), having the Recent south and east Australian *Cytherea kingi* Gray as genotype, and in addition containing *lamarcki* Gray, *disrupta* Sowerby and the fossil *submultistriata* Tate. Any discussion as to the affinities of *Notocallista* must therefore centre on *kingi*, though obviously close relatives may be highly significant in showing what characters are of systematic importance.

N. kingi is fairly large for the family, specimens being commonly 50–60 mm. long. The specimens examined can be divided on their shape into two groups: (1) well inflated, stoutly built, broadly oval shells with relatively high, broad umbones and wide hinge-plate, Twofold Bay, New South Wales, and Port Phillip Bay, Victoria; (2) more longitudinally oval shells, inclined to be lighter built, having relatively lower umbones, a narrower hinge-plate, and therefore shorter cardinal teeth, Tasmania and Gulf of St. Vincent. Each

locality has its own type of colour pattern; curiously, the Tasmanian shells, though near group 2 in shape, have patterns very like those of the Port Phillip Bay shells.

Following Iredale's (1924, p. 210) observations at the British Museum, the stout shells of group 1 can be taken as *kingi* and the more elongate ones of group 2 as subspecies *lamarcki* Gray. Gray's original description of *Cytherea kingi* reads: "Shell ovate, heart-shaped, white or pale brown with dark rays, each formed of several narrow lines, the umbones white, 1 inch long, 8/10 inch high." This description suggests that it was written from juveniles of the Port Phillip Bay kind.

The writer's former description of *Notocallista* (Marwick, 1924, p. 592) was based on specimens of the New Zealand *multistriata* and *parki*, together with a specimen of the Tasmanian *diemenensis* wrongly identified as *kingi*. It is therefore quite misleading.

The surface of the adult *kingi* is almost smooth, being very irregularly and weakly concentrically striated, even on the juvenile such concentric striae as are developed are irregular. The periostracum on some specimens, e.g., from Twofold Bay, New South Wales, is well developed and has a high glaze, the posterior area in many shells bearing fine radial wrinkles like those of *V. chione* L. The periostracum of others, however, especially some from southern districts such as Port Phillip Bay is not firmly attached and peels off, leaving the shell with a dull chalky-looking surface very like that underlying the periostracum of *V. chione*.

The hinge of *N. kingi* appears to the writer to agree in every significant respect with that of *V. chione*. Take Jukes-Browne's criteria: there is no well-defined channel leading back from the anterior lateral pit; a shallow depression, about normal to the long axis of the pit, leads down to the inter-cardinal socket, the anterior cardinal being undercut to the same small extent in both species; the left posterior cardinal of *kingi*, as of *chione*, is relatively short, thin, and closely joined to the nymph.

Owing to its broader hinge-plate, the cardinal teeth of *kingi* (s. str.) are in general relatively longer than those of *chione* and their set differs (as measured by the more nearly vertical anterior cardinal). That the difference is unimportant is shown by the hinge of subspecies *lamarcki*, especially of the lightly built Gulf of St. Vincent shells. (See Pl. 11, figs. 2, 3.)

The left anterior lateral tooth of both *kingi* and *chione* continues up towards the umbo as a definite ridge, simulating a cardinal. The presence of a similar "buttressed" tooth in the West American Oligocene *Pitar arnoldi* Weaver was the outstanding feature used by N. M. Tegland (1929, pp. 276, 280) to differentiate *Katherinella* as a new subgenus of *Pitar* which was said to lack the buttress.

Grant and Gale's suggestion (1931, p. 347), that the anterior lateral of the Pitarinae is really a cardinal tooth moved forward is rather attractive when one considers a hinge like that of *Notocallista*, in which the tooth in question extends well up under the umbo.

Ontogenetic evidence, however, is against the idea. On young *multi-striata* and *parki* of 2 mm. diameter the left anterior lateral is a small, bluntly conic tubercle without any ridge or buttress, apparently originating as an independent growth on the hinge-plate. The buttress develops later and becomes quite prominent (Pl. 10, figs. 1-3). Nor does phylogenetic evidence support the cardinal nature of the anterior lateral. Cretaceous species do not have the tooth buttressed any more than, if as much as, many later species do. The buttress has apparently developed as the anterior margin of the socket into which the right anterior cardinal fits.

The pallial sinus of both *kingi* and *chione* is obliquely truncated to form a rather sharp point though that of *chione* is less ascending, and bulges out along its lower boundary to be more nearly equilateral.

Finally, in both species the pedal-retractor scar is well separated from that of the anterior adductor.

In view of this remarkably close agreement in essential characters, one is tempted to conclude that the two species are quite closely related, differing chiefly in shape, and that *Notocallista* must take the place, without the seniority of *Callista*, which is not legally available (Stewart, 1930, p. 239).

The position, however, is not so simple, and when the species of the two new groups *Striacallista* and *Fossacallista* are considered, the European *chione* seems with equal if not greater probability to be a remarkably close parallelism to *Notocallista*. *Fossacallista* is an Oligocene and Miocene group that lived in Australian and New Zealand seas. Besides having a hinge closely similar to that of *Chionella* (Pl. 10, figs 9, 10), it has a sunken ligament, confluent pedal retractor (Pl 14, fig. 10a), and ascending pallial sinus with a rounded end. The left posterior cardinal is not so well separated from the nymph as that of *Chionella*, but in some species a well-defined though shallow groove separates them. *Fossacallista* grades through such species as *N. mollesta* n.sp. into *Striacallista*, which has a high ligament, separate pedal retractor (Pl. 12, fig. 5a) and truncated sinus; and from *Striacallista* the change to *Notocallista*, which also has these characters, is mostly one of increase in size and obsolescence of sculpture.

If the parallelism of *kingi* and *chione* is an actual fact, then *Notocallista* must be a recent development from *Striacallista* for it is not known as a fossil. On the other hand, if *chione* is really as closely related to *kingi* as it superficially appears to be, that is, if it is a *Notocallista*, then the European fossil occurrences take the group back to the Miocene, and the American probably to the Eocene.

The geological factor favours solving the problem by parallelism, of which many cases are known in the family.

To trace the origin of the European *chione*, account must be taken of the strongly sculptured *Costacallista*. The hinges of species of this group are remarkably constant and agree in every respect with that of *chione*. The groups also agree in size, shape, lunule, ligament, pedal retractor and pallial sinus. *Costacallista* has been traced back by Palmer to weakly sculptured species in the Eocene [*C.*

perovata (Conr.)], so is probably much more closely related to *chione* than is *Chionella*, and seems more likely to have given rise to the *chione* stock through obsolescence of sculpture than does *Chionella* through evolution of the hinge, ligament, pedal retractor and pallial sinus. On this argument *Chionella* appears to be off the main line of descent of *chione*, which, however, remains a parallel development with *kingi*.

Although *Macrocallista* Meek (monotype *V. gigantea* Gmelin, Florida) has a smooth outer surface like *chione*, it differs in its very elongate shape and also in having a bifid left anterior cardinal; moreover the stocks have been distinct throughout the Tertiary.

The relationship of *Notocallista* to *Pitar* Römer is difficult to determine. As can be seen from Stewart's studies (1930, p. 232) the precise limits of *Pitar* are not easy to define and many of the fossils that have been classed under it are doubtful members. No specimens of the genotype were available in New Zealand for this revision, but specimens of the Aquitanian *P. rudis* (Philippi) and *P. lamarchi* (Agassiz) in the Geological Survey Collection seem to possess the essential characters of *P. tumens* and to be undoubtedly *Pitar* s. str. *P. nuttallopsis* (Conr.) from the Yorktown Miocene agrees closely with *rudis* and carries the stock to Eastern U.S.A., where it is strongly represented back to the Eocene (Palmer, 1926).

Jukes-Browne (1914, p. 61) in his diagnosis of *Pitar* (sensu lato) described the pedal retractor as confluent with the adductor and this certainly holds for the three Tertiary species just mentioned. It also holds for the genotypes of the subgenera *Capitaria*, *Pitarina* and *Agriopoma*. In all the specimens examined of *Macrocallista*, *Microcallista*, *Costacallista*, *Notocallista* s. str. and all the undoubtedly "*Callista*" species the pedal retractor is separated from the adductor. If the character, however, be used as a deciding criterion between *Pitar* and the *Macrocallista*-*Costacallista*-*Notocallista* groups, then *Chionella* and the new group *Fossacallista* must go with *Pitar*. Separation of *Chionella* from *chione* causes no trouble, but *Fossacallista* is quite evidently closely related to *Striacallista* and this, with its probable offshoot *Notocallista*, must go with the "*Callista*" groups. The character, therefore, of confluence or separation of the pedal retractor and the anterior adductor cannot be used absolutely, though it certainly is a very useful guide.

CONCLUSIONS.

From the foregoing discussion it can be seen that the exact systematic affinities of *Venus chione* are uncertain. In almost all its characters it agrees with *Notocallista*, but there are grounds for believing that this is due to parallelism. *V. chione* has less in common with *Chionella* or *Macrocallista* than with *Costacallista* (type *V. erycina* L.), from which it may be an offshoot through obsolescence of the sculpture.

Jukes-Browne and Palmer favoured retention of *Callista* for *chione* by suspension of the International Rules, but Stewart (1930, p. 239) has pointed out the rather chequered history of the name and its consequent unsuitability.

Perhaps *chione* will find a home under *Megapitaria* Grant and Gale as a subgenus of *Costacallista*. No specimens of the genotype, *Cytherea aurantiaca* Sowby., were available to the writer for comparison, but Gray's figure of his species, *squalidus*, which Grant and Gale included in *Megapitaria*, shows a shell very like *chione*.

Grant and Gale (1931, p. 346) have solved the difficulty of choosing between *Macrocallista*, *Megapitaria*, *Amiantis*, *Hysteroconcha* and *Pitar* as genera by suggesting that *Pitar*, the oldest name, should be taken as a genus and all the other groups with this general type of hinge included as equivalent subgenera. This seems to be the only good alternative to recognising these and such other groups as *Chionella*, *Calipitaria*, *Tivelpna*, *Costacallista* and *Notocallista* as independent genera. Each course has its advantages; but as our knowledge of the many lineages increases, the tendency will be to elevate all those mentioned and others to generic rank. As noted by Stewart, the use of sectional subdivisions of subgenera is rather clumsy for citation and is not sanctioned by the International Rules; consequently, the best plan seems to be greatly to restrict the older, wide, "Lamarckian" genera and to use genera of intermediate size with only subgeneric divisions. From this point of view, the best classification for *chione* Linné appears to be under *Costacallista* (*Megapitaria*).

Australian and New Zealand shells at present classed as *Notocallista* fall into three main groups which can be treated as subgenera under the genus *Notocallista*. These subgenera, *Notocallista* s. str., *Striacallista* and *Fossacallista*, typically are easily separable, but their respective limits are difficult to define because of borderline species that combine characters of two groups. Although this is a source of difficulty in drawing up a concise key to the species, it should not act as a barrier to the recognition of systematic groups. The three here recognised are of somewhat unequal value, for *Fossacallista* is much easier to separate from *Notocallista* than is *Striacallista*.

According to the evidence so far gained, *Fossacallista* is probably the oldest group, being related to the European *Chionella*, which has in its juvenile stage similar fine concentric ridges. *Fossacallista* lived in Australian and New Zealand seas during the Oligocene and Miocene, but became extinct in both regions before the Pliocene. *Striacallista* probably developed from *Fossacallista* in Australia during the Oligocene (*N. cudmorei* n.sp.), but it did not reach New Zealand until the Lower Pliocene, when it filled the place formerly occupied by *Fossacallista*. *Notocallista* s. str. probably split off from *Striacallista* in Australia about the Upper Pliocene for the oval variety of the Kalimnan *N. submultistriata* has much in common.

Two other New Zealand Tertiary members of the Pitarinae are discussed below. *Hyphantosoma* Dall and *Rohea* n. gen. *Hyphantosoma* is a West Indian group with zig-zag sculpture. The New Zealand species, *sculpturatus* Marshall may have developed this peculiar sculpture independently. Zig-zag colour patterns occur widely in the family and perhaps indicate the common base from which the grooves developed. However, until more definite evidence to the contrary is available, *sculpturatus* should be classed under *Hyphantosoma*.

Although the affinities of its hinge are with the European Cretaceous *Callista*, *Rohea* could be explained, because of the similar sculpture and ligament as an offshoot from *Fossacallista*. The sculpture of the whole subfamily, however, is so simple that resemblance in this respect does not carry much weight, therefore the evidence offered by the hinge has been given preference.

STRATIGRAPHICAL TABLES.

A.—New Zealand.

	<i>Striacal- lista.</i>	<i>Fossacal- lista.</i>	<i>Costacal- lista.</i>	<i>Hyphanto- soma.</i>	<i>Rohea.</i>
Recent	<i>multi- striata</i>				
Pliocene	<i>multi- striata</i>				
Upper Miocene ..		<i>makocensis</i>			
Lower Miocene ..		<i>tersa</i>			
		<i>parki</i>			
Oligocene		<i>parki</i>		<i>sculptur- atus</i>	
		<i>icatti</i>			
		<i>tecta</i>			
Eocene			<i>hectori</i>		<i>trigonalis</i>

B.—Australia.

	<i>Notocallista.</i>	<i>Striacallista.</i>	<i>Fossacallista.</i>
Recent	<i>kingi</i>	<i>diemenensis</i>	
	<i>lamarecki</i>	<i>disrupta</i>	
Pliocene		<i>submultistriata</i>	
Miocene-Oligocene ..		<i>mollesta</i>	<i>tatei</i>
		<i>pestis</i>	<i>ancisa</i>
		<i>lutea</i>	<i>opima</i>
			<i>singletoni</i>
		<i>rudmorci</i>	<i>crigug</i>
			<i>eburnea</i>

KEY TO GENERA AND SUBGENERA DESCRIBED BELOW.

- I. Sculpture of zig-zag grooves. *Hyphantosoma*
- II. Sculpture of concentric grooves and ridges.
 - A. Anterior laterals distant from cardinals, right anterior cardinal long, hinge plate flat. *Rohea*
 - B. Anterior laterals close to cardinals, right anterior cardinal short, hinge plate excavated
 1. Sculpture strong. Concentric ridges broad and high. *Costacallista*
 2. Sculpture weak or obsolete. Concentric ridges low, generally fine.
 - (a) Pallial sinus rounded, pedal retractor confluent, groove defining left post cardinal well marked, ligament deeply sunk. *Fossacallista*
 - (b) Pallial sinus truncate, pedal retractor separate, groove defining left post cardinal weak or absent, ligament shallow.
 - (1) Large shell (adults 40–60 mm. long); periostracum thick, inclined to blister and peel; regular concentrics at extremities of juvenile only, elsewhere weak irregular concentrics; ligament under $\frac{1}{2}$ total length of shell. *Notocallista* s. str.

- (2) Small shell (adults 12–45 mm. long, many 30 mm.); periostracum thin, closely attached, juveniles with persistent grooves, but always with extremities regularly grooved; ligament $\frac{1}{4}$ (or over) total length *Striacallista*

SYSTEMATIC DESCRIPTIONS.

Genus NOTOCALLISTA Iredale.

1924. *Proc. Lin. Soc. N.S.W.*, vol. 49, p. 182.

Genotype (by original designation): *Cytherea kingi* Gray, Recent, south and east Australia.

1.—Subgenus NOTOCALLISTA s. str.

Notocallista (Notocallista) kingi (Gray). Plate 10, fig. 14; Plate 11, figs. 4, 5, 9.

1827. *Cytherea kingii* Gray, app. to King's *Narrative of a Survey . . . of Australia*, vol. 2, p. 476.

For synonymy see Pritchard and Gatliff, *Proc. Roy. Soc. Vic.*, vol. 16 (n.s.), pt. 1, p. 130.

Recent: Twofold Bay, N.S.W.; Port Phillip Bay, Victoria.

These and other localities given below are of actual specimens examined, and therefore they are incomplete.

Notocallista (Notocallista) kingi subsp. **lamarecki** (Gray). Plate 11, figs. 1–3.

1838. *Cytherea lamareckii* Gray, *Analyst*, vol. 8, p. 308.

Recent: North Coast, Tasmania; Gulf of St. Vincent, South Australia.

2.—Subgenus STRIACALLISTA nov.

Genotype: *Cytherea multistriata* Sowerby, Recent and Pliocene, New Zealand.

Shell rather small, inequilaterally subtriangular to suboval. *Lunule* defined by an incised line. Surface shining, bearing fine concentric grooves that tend to obsolesce medially. Hinge like *Notocallista*, left posterior cardinal confluent with nymph, left anterior lateral buttressed, right anterior and posterior cardinals not bridging. Pedal retractor separated from the anterior adductor. Pallial sinus rather short, ascending, broadly truncate.

A.—New Zealand Species.

Notocallista (Striacallista) multistriata (Sowerby). Plate 10, figs. 1–3; Plate 12, figs. 1–3.

1851. *Cytherea (Callista) multistriata* Sowerby, *Thes. Conch.*, vol. 2, p. 628, pl. 136. f. 177.

1913. *Macrocallista multistriata* Sowby.; Suter, *Manual*, p. 982, pl. 62, fig. 3a.

1927. *Paradione (Notocallista) multistriata* (Sowby.); Marwick, *Trans. N.Z. Inst.*, vol. 57, p. 592, figs. 70, 71, 72.

Recent: Throughout New Zealand, 5–100 faths.

Upper Pliocene: Castlecliff and Kai-iwi, in arenaceous mudstone.

Lower Pliocene: G.S. 1609—Timmins Creek, Mangamaire, Mangahao River, 8 miles south-west of Pahiatua. G.S. 2811—Road bridge, Matarua Creek, 5 miles west of Pahiatua. Starborough Creek, Awatere Valley.

Dr R. S. Allan has carefully collected from the many different beds in the Castlecliff—Kai-Iwi section, and his specimens show clearly that the apparent variability of *multistriata* from this locality has been due to careless collecting. Actually the shells from each bed are remarkably constant in characters and only in two beds, 6 and 10, were two forms collected. Four more or less distinct shapes can be distinguished and the following table shows their distribution.

Bed.	Trigonal.	Elongate-trigonal.	Elongate.	Oval.	No. of valves.
1			blue clays		3
2				shell bed	3
3c				shell bed	3
4a				sandy blue clays	3
5			blue clays		1
6		<i>egenum</i> sands		<i>egenum</i> sands	6, 4
7				shell bed	
10	blue clays	blue clays			1, 1
11				shell bed	6
13	fossilif. blue clay				6
15		blue clays			2
18				gritty shell bed	1
20		fossilif. grits			1
22		cement stone band			1

From this it can be seen that the oval shell occurs fairly consistently in the shell beds and coarse bands, while the others occur mostly in fine muddy beds. Most Recent specimens seen (Awanui Bay, Great Barrier Island and Foveaux Strait) belong to the trigonal form, the northern shells differing from the southern only in having a bright, well-defined colour pattern. Shells in the Auckland Museum from mud, Cook Strait, 2½ miles north-west from Waikanae, are of highly elongate shape and agree very closely indeed with those from beds 1 and 5. Those classed as elongate-trigonal are intermediate in shape between typical trigonal and elongate forms. It may be that these differences in shape are directly due to the environment, but this does not explain the absence of the oval form from Recent faunules. Lower Pliocene shells from near Pahiatua seem to combine the characters of the oval and the trigonal forms, so it may be that we have here the emergence of a new species. In bed 6 at Castlecliff, the *egenum* sands, the elongate-trigonal and the oval forms both occur without grading, thus tending to confirm the indications that the two forms are distinct. Shell beds are liable to contain forms from different faunules, for many of them must be concentrations of mullusca brought about by the removal of the sands in which they were buried by increase in the rate of bottom currents; but the *egenum* sands do not appear to be of this nature.

A specimen in the Geological Survey collection from Starborough Creek is strongly subtrigonal, having broad, high beaks, a

narrow posterior end and a greatly inflated shell. In shape it resembles the subtrigonal form of the Australian Lower Pliocene *N. submultistriata* though its escutcheon is not so flat. Among the Pahiatua shells mentioned as showing a gradation from oval to trigonal are some strongly subtrigonal, thus approaching the Starborough Creek shell. Further collecting, however, is necessary before the systematic recognition of this form could be justified.

The oval form from Castlecliff is so distinct that it is here recognised as a separate subspecies.

Notocallista (Striacallista) multistriata ovalina n. subsp. Plate 12, figs. 4, 5, 5a.

Shell distinguished from *multistriata* by its oval instead of subtrigonal form, most apparent in its broadly convex posterior end. The hinge shows no consistent differences, but the sculpture of fine regular ridges persists across the disk, while that of *multistriata* is obsolete medially, the ridges becoming weak and highly irregular. The dorsal crest in the left valve is often raised particularly high.

Holotype in Canterbury Museum.

Length, 29.5 mm.; height, 22.4 mm.; inflation (1 valve), 7.5 mm.

Upper Pliocene: Beds 2, 3c (type), 4a, 6, 7, Castlecliff; beds 11, 18, Kai-Iwi (R. S. Allan coll.).

For a discussion on this subspecies see under *multistriata*.

B.—Australian Species.

Notocallista (Striacallista) diemenensis (Hanley). Plate 12, figs. 6-8.

1844. *Cytherea diemenensis* Hanley, *P.Z.S.*, pt. 12, p. 110.

1903. *Meretrix planatella* Lamk., Pritchard and Gatliff, *P.R.S. Vic.*, vol. 16 (n.s.), p. 129. (Not of Lamk.)

Recent: Tasmania; Western Port, Victoria, 8 faths. (C. J. Gabriel); Gulf of St. Vincent, South Australia.

By examining the types, Hedley (1913, p. 270) has shown that the earlier *planatella* Lamarck, thought by some to be synonymous with *diemenensis* (Smith, Challenger, XIII, p. 136) really is a young *Costacallista* from north-west Australia. The sculpture of *diemenensis* is coarser than that of *multistriata* and the ligament has much lower walls.

Notocallista (Striacallista) disrupta (Sowerby). Plate 12, figs. 12, 14, 15.

1853. *Cytherea disrupta* Sowby., *Thes. Conch.*, vol. 2, p. 743, pl. 163, f. 208, 209.

1885. *Cytherea (Callista) disrupta* Sowby., Smith, *Challenger*, vol. 13, p. 135, pl. 1, f. 4-4e.

Recent: Specimens seen came from Sydney Harbour and from Calloundra, Queensland, the latter considerably less elongated.

Iredale (1924, p. 210) recorded typical *disrupta* from Twofold Bay and noted that "Tasmanian shells named *disrupta* varied a little further while Sydney shells referred to this species should have a distinctive name." Later (1929, p. 338) he advocated the use

of *laevigata* Sowerby for the Sydney and Calloundra shells. In describing his *Venus laevigata* (*Thes. Conch.*, vol. 2, p. 103) Sowerby gave three figures, 156, 157, and 158. Figure 156 represents the exterior of a left valve 27 mm. x 19 mm. with a long, straight, relatively high posterior dorsal margin and a straight, steep, anterior dorsal margin. In shape it is thus not at all like the Sydney shells allotted to *N. disrupta* which have a strongly convex posterior dorsal margin and a strongly concave anterior dorsal margin. The colour pattern of Sowerby's figure 156, namely, rays formed of black zig-zags on a yellowish ground, is not that of *Notocallista* but of *Eumarcia nitida* (Q. and G.), which, moreover, has a high, straight dorsal margin, though, to be sure, the anterior end projects more. Sowerby's figures 157 and 158 are of a left valve measuring 39 mm. x 25 mm. They show a hinge with three equally diverging cardinal teeth and no trace of an anterior lateral, exactly, indeed, as in *Eumarcia nitida* and quite unlike *Notocallista*. Moreover, the interior colour, a pale salmon band along the pallial line and filling the sinus, added to the hinge evidence, leaves no doubt whatever that the shell is a *Eumarcia*. Accordingly, *laevigata* is not available for any groups of *Notocallista*.

It seems possible that a form of the southern *diemenensis* has been identified by authors as *disrupta*. Thus Iredale mentioned "*disrupta* from Tasmania," yet May in his Check List recorded only *kingi* and *diemenensis* (as *Macrocallista*). Also Pritchard and Gatliff in their Catalogue of the Marine Shells of Victoria recorded *Meretrix disrupta* from Port Phillips Heads, with the remark: "We agree with Mr. Hedley in regarding this as distinct from *planatella* (= *diemenensis*), though very closely related."

Now Sowerby's figure 20 of *disrupta* shows a shell 47 mm. x 35 mm. which he described as "*laevigata* . . . *concentrice tenuiter striata* . . . *lunula excavata*," emphasising in his notes the excavated lunule. Calloundra shells agree in size, shape, and excavated lunule, and the Sydney shells differ from these only in being more elongate, though both have a much less conspicuous colour pattern than Sowerby's figure. *N. diemenensis*, on the other hand, measures about 32 mm x 24 mm., often much less, is concentrically ridged and has an almost straight lunular margin. It is unlikely that there would be any hesitation such as suggested by Pritchard and Gatliff about separating shells like the Calloundra and Sydney ones from *diemenensis*. Moreover, the southern shells lack the several deep growth-furrows that so characterize Sydney and Queensland ones.

However, the sorting out of the true *disrupta* and its regional relatives cannot be carried out with the material available in New Zealand. All that can be done in this paper is to remove the Calloundra and Sydney shells from *laevigata* and provisionally place them back under *disrupta*. It is suggested that the true *disrupta* is a brightly patterned shell having the form of the Calloundra ones, but being somewhat less inflated. The Sydney ones, being consistently more elongate, represent a distinct subspecies.

For careful copies of Sowerby's figures of *disrupta* and *laevigata* I am indebted, through the kind agency of Mr. F. S. Colliver, to Mr. A. C. Frostick of Melbourne.

Notocallista (Striacallista) submultistriata (Tate). Plate 12, figs. 9-11, 13.

1887. *Cytherea submultistriata* Tate, *Trans. Roy. Soc. Sth. Aust.*, vol. 9, p. 160, pl. 18, figs. 6, 8.

1924. *Notocallista submultistriata* (Tate); Iredale, *Proc. Lin. Soc. N.S.W.*, vol. 49, p. 210.

Pliocene (Kalimnan): Upper beds Muddy Creek (type). Jimmy's Point (F. A. Singleton). Forsyth's Grange Burn. Kalimna.

Two different shapes are common in this species, one a fairly regularly inflated form with erect umbones, the other, generally smaller, is more inflated, has a flattened escutcheon bounded by a rounded ridge, more forward-curved umbones and a narrower posterior end, making the outline more subtrigonal. Both forms were figured by Tate, and of the eight specimens examined during the present revision six belong to the second subtrigonal variety. Whether the differences merit systematic recognition should not be decided without examining the field occurrences of a large number of specimens.

From the Recent *disrupta* the Pliocene *multistriata* is readily distinguished by its different shape, being always relatively shorter in front and having a much less excavated lunule. Further, the left posterior cardinal of *submultistriata* is considerably longer and stronger than that of *disrupta*. However, *submultistriata* appears undoubtedly to be directly ancestral to the Recent shell.

Notocallista (Striacallista) lutea n.sp. Plate 13, figs. 5, 6.

Shell small, moderately inflated, thin, elongate, beaks not very prominent. Surface shining, with very fine concentric grooves, many persisting across the disk. Left posterior cardinal joined to the nymph without a separating groove. Hinge-plate lightly built. Ligament not deeply set, the walls low, the posterior dorsal marginal ridge meeting them at about half height. Pedal retractor separated from the adductor by a very short line. Pallial sinus ascending, roundly truncated.

Holotype in Auckland Museum (ex Finlay collection).

Length, 13.8 mm.; height, 10 mm.; inflation (1 valve), 3.5 mm.

Oligocene-Miocene: Lower beds (Balcombian) Muddy Creek, Vic.

This shell has been indentified as *N. eburnea* (Tate), which it resembles in size and general appearance. It can readily be separated, however, by its shallow ligament and more elongate shape. It further differs from *eburnea* in the narrower, subtruncate sinus, separated pedal retractor, more persistent and finer sculpture and less inflation. The differences are more accentuated in juveniles, especially because of the marked inflation of *eburnea*.

Notocallista (Striacallista) cudmorei n.sp. Plate 13, figs. 1, 2.

Shell rather small elongate oval, beaks inconspicuous. Sculpture of fine concentric grooves, 6 to 8 per mm., becoming weak and irregular and some obsolete medially. Hinge very like that of

multistriata, except that the right posterior cardinal is longer and narrower. The ligament is set at about the same depth as in *multistriata* but the walls are slightly lower, not being raised in a dorsal crest. The sinus also is truncated and similar in shape to that of *multistriata*. The pedal retractor is separated from the adductor.

Holotype presented to National Museum, Melbourne, by Mr. F. A. Cudmore.

Length, 19 mm.; height, 12.5 mm.; inflation (1 valve), 4 mm.

Oligocene-Miocene: Lower beds, Table Cape, Tasmania.

N. cudmorei presents an extraordinary likeness to the New Zealand Recent and Pliocene *multistriata*. It can be distinguished by the low ligamental walls not forming a dorsal crest and by the less-conspicuous beaks, but the differences are relatively small and individual variations might cause difficulty in identifying a given specimen. There can be little doubt that *N. cudmorei* is an early member of the stock that colonised New Zealand from Australia about the late Miocene or early Pliocene.

***Notocallista (Striacallista) mollesta* n.sp.** Plate 13. figs. 7-9.

Shell of average size for the subgenus, suboval, beaks low. Sculpture of fine, regular, concentric grooves and bevelled ridges 4 to 5 mm. persisting across the disk. Ligament well sunk with high walls. Hinge teeth like those of *multistriata* except that the left posterior cardinal of the holotype is more separated from the nymph. Pedal retractor separated from the adductor. Pallial sinus ascending, roundly truncated.

Holotype in collection of N.Z. Geological Survey.

Length, 26.5 mm.; height, 19.5 mm.; inflation (1 valve), 6.5 mm.

Locality: 400-500 ft., Abattoirs bore, Adelaide. Age uncertain.

The deep-set ligament and well-defined left posterior cardinal indicate classification under *Fossacallista*, but the sinus is inequilateral and shows traces of truncation, and the pedal retractor is not confluent with the adductor. The persistent sculpture is reminiscent of some early *Fossacallista*, but one of the specimens has a medial patch of obsolescent sculpture. Therefore the well-defined adult ridges may be an anagenetic feature derived from a sub-smooth stage. *N. mollesta* is not clearly separable from the next species *N. pestis*, under which the matter is further discussed.

***Notocallista (Striacallista) pestis* n.sp.** Plate 13, figs. 3, 4.

Shell about average size for the subgenus, suboval to subtriangular, narrowed posteriorly, beaks moderately conspicuous, rather narrow. Surface shining, posterior and anterior parts bearing concentric grooves and ridges, about 4 per mm., but these are very irregular and die out over the middle of the disk. Ligament shallow, its walls low. Hinge close to that of *multistriata*. Pedal retractor close to the adductor but separated from it. Pallial sinus roundly truncate.

Holotype in Auckland Museum (ex Finlay Collection).

Length, 27 mm.; height, 19 mm.; inflation (1 valve), 5.5 mm.

Locality: 400–500 ft., Abattoirs bore, Adelaide. Age uncertain.

Although the holotypes of *N. pestis* and *N. molesta*, which come from the same locality, are, on the criteria used in this paper, almost, if not quite, subgenerically separable, paratypes seem to show a gradation between the two species. Of the 9 specimens examined from the Abattoirs bore no clear-cut groups could be formed. The only two characteristic specimens of *N. molesta* have a sunken ligament and persistent sculpture. They also have a fairly regularly oval outline. The other specimens have persistent sculpture and an oval shape, but they have a shallow ligament and so have been classed under *pestis*. The other five specimens with shallow ligaments and obsolescing sculpture differ considerably among themselves in shape, in the pallial sinus, in the degree of separation of the pedal retractor from the adductor, and of the left posterior cardinal from the nymph. The deep ligament and separated left posterior cardinal of the type of *N. molesta* are characters of *Fossacallista*, but the pedal retractor is not confluent and the pallial sinus is roundly truncate. Thus as well as showing mixing of specific characters, the Abattoirs bore collection shows blending of the subgenera *Fossacallista* and *Notocallista*. The most convenient refuge at present is to explain the mixture as due to hybridisation of stocks, but it is somewhat disturbing to find characters that apparently have generic (or subgeneric) significance in the rest of the family, yet that cannot show consistent specific divisions in this small group.

The specimens were obtained from some 100 ft. or so of beds in a bore, and probably more than one horizon is represented (N. H. Woods, 1931, p. 147), but this does not explain away all the anomalies.

N. pestis agrees closely with *multistriata* in shape, sculpture, and hinge, the most consistent difference being the more sharply truncate sinus of *multistriata*.

3.—Subgenus FOSSACALLISTA nov.

Genotype: *Paradione (Notocallista) parki* Marwick. Awamoan (Low. Miocene), New Zealand.

Shell rather small, suboval. Lunule defined by an incised line. Surface shining, finely concentrically grooved, tending to be smooth medially. Hinge like *Notocallista*, but the left posterior cardinal tends to be less closely welded to the nymph, some specimens showing a well-defined groove between the two. Ligament deeply sunk with high walls which, however, are scarcely raised above the well-marked posterior marginal ridge. Pedal retractor confluent with the anterior adductor. Pallial sinus moderate, ascending, rounded at the end.

Readily distinguished from *Notocallista* and *Striacallista* by the sunken ligament, confluent pedal retractor, and rounded pallial sinus. In these characters it agrees with *Chionella*, and relationship to this group is further indicated by the shallow groove that in some specimens separates the left posterior cardinal from the nymph. Thus

Fossacallista, if considered by itself, could well be classed under *Chionella*, but gradation towards *Striacallista* and thence to *Notocallista* suggests that this persistent southern stock should be recognised as a separate generic group under the oldest name, *Notocallista*.

Λ.—New Zealand Species.

***Notocallista (Fossacallista) tecta* n.sp.** Plate 14, figs. 5, 6.

Shell small, more elongate-oval than *parki* and having very fine regular grooves about 8 per mm. persisting over the whole disk. The lunule is more excavated than that of *parki*, so that its dorsal margin is noticeably more concave, in the manner of *N. disrupta*.

The pallial sinus does not reach the middle, tapers, ascends and is rounded at the end.

Holotype in Auckland Museum (ex Finlay Collection).

Length, 17.5 mm.; height, 12 mm.; inflation (1 valve), 4 mm.

Oligocene: Chatton (type). G.S. 1897—Wendon. G.S. 1821—Wharekuri greensand.

***Notocallista (Fossacallista) watti* n.sp.** Plate 14, figs. 12, 13.

Shell considerably larger than *parki*, umbones wide, prominent. Surface shining and nearly smooth, very fine concentric grooves 5 to 6 per mm. distally, becoming obsolete and further apart medially. Young shells of the same size as *parki* are more elongate, but the adults have a similar shape, being distinguished chiefly by their smoother surface.

Holotype in Collection of N.Z. Geological Survey.

Length, 32 mm.; height, 25.3 mm.; inflation (1 valve), 9 mm.

Oligocene: G.S. 1473—Upper part of limestone, Trig Z, Otiake.

This species is named in honour of the late John Watt, my first companion in the Otiake district.

***Notocallista (Fossacallista) parki* (Marwick).** Plate 10, fig. 10; Plate 14, figs. 8, 9, 10, 10a.

1920. *Paradione (Notocallista) parki* Marw., *Trans. N.Z. Inst.*, vol. 57, p. 593, figs. 66–69.

Upper Oligocene: Clifden band 6a; ? Clifden, east side, C; Target Gully glauconitic sandstone; sandstone, All Day Bay; Parson's Creek, Oamaru (type).

The grooves are generally 4 to 5 per mm. and so somewhat coarser than those of *watti* and noticeably more so than those of *tecta*.

***Notocallista (Fossacallista) tersa* n.sp.** Plate 14, figs. 4, 7.

Shell rather small, more elongate oval than *parki* and nearer the shape of *tecta*, from which it differs in being more acuminate posteriorly. Sculpture of fine concentric grooves about the strength of *tecta* but very irregular, obsolete medially. Lunular margin slightly concave, intermediate between *tecta* and *parki*. Hinge with a very small right posterior cardinal and with the left posterior cardinal coalescing with the nymph. Pedal retractor confluent with the adductor, the junction somewhat restricted. Pallial sinus roundly truncated.

Holotype in Auckland Museum (ex Finlay Collection).

Length, 20 mm.; height, 13 mm.; inflation (1 valve), 4.8 mm.

Locality: Shell bed, Target Gully, Oamaru.

A single specimen 29 mm. long in the Geological Survey Collection, from Target Gully, has coarse sculpture and rather straight lunular margin like *parki*, but the long shape of *tersa* and *tecta*. Its pallial sinus is rounded in front. Judged by its colour it probably came from the glauconitic sandstone underlying the shell-bed. *N. parki* occurs in this bed and the specimen may represent a transition or a hybrid between *parki* and *tersa*, with which it can be classed because of its shape.

Notocallista (Fossacallista) makoensis (Marwick). Plate 13. fig. 12.

1931. *Paradione (Notocallista) makoensis* Marw., *N.Z. Geol. Surv. Pal. Bull.*, 13, p. 78, figs. 99, 100.

Upper Miocene (Taranakian): 1324, Waikohu Survey Dist. 1350, Bruce Ridge Road, Tokomaru Survey Dist. 2313, Ngahape Stream, Motuotaraia Survey Dist.

The interior characters of this species have not yet been determined, so its position in *Fossacallista* is uncertain. However, the general probabilities seem to indicate a degenerate representative at the end of the *Fossacallista* reign rather than the first representative of the Australian *Striacallista* stock in New Zealand.

B.—Australian Species.

Notocallista (Fossacallista) eburnea (Tate). Plate 13, figs. 16–18.

1887. *Cythera eburnea* Tate, *Trans. R.S. Sth. Aust.*, vol. 9, p. 160. pl. 18, fig. 7.

Shell small, fairly well inflated, having a high, arched posterior dorsal margin. Surface smooth and shining, sculpture obsolete over most of the disk but regular concentric grooves on the juvenile and irregular weak ones distally on the adult.

Left posterior cardinal well developed though narrow, tending to be bounded along its upper side by a groove. Hinge-plate lightly built, so that the left anterior lateral is slender and set in a hollow. Right anterior lateral pit with an extremely shallow groove leading to the cardinal socket. Ligament deeply sunk, with high walls, posterior dorsal marginal ridge well defined. Pedal retractor confluent, pallial sinus relatively short and very broad, rounded at the end.

Oligocene-Miocene: River Murray Cliffs below Morgan (Janjukian).

Notocallista (Fossacallista) opima n.sp. Plate 13, figs. 13–15.

Shell small, greatly inflated, beaks broad and prominent. Surface shining, with a few irregular grooves persisting across it from the distal parts, where they are well spaced and fairly regular. Hinge-plate narrow, left posterior lateral bounded dorsally by a groove. Left anterior lateral relatively slender, sharply pointed.

Right anterior lateral pit small, median cardinal low down on the hinge. Ligament deeply sunk. Pedal retractor confluent. Pallial sinus ascending, very wide, tapering rapidly, broadly rounded at the end.

Holotype in Melbourne National Museum Collection.

Length, 13.3 mm.; height, 11.2 mm.; inflation (1 valve), 4.4 mm.

Oligocene-Miocene: Balcombe Bay, Victoria (Balcombian).

N. opima is easily distinguished from *eburnea* by its much greater inflation, more oval outline and broader, more prominent beaks. The sculpture is not so obsolete as that of *eburnea* and the lunule is relatively shorter and broader. Internally the species agree well, so they must be closely related.

Notocallista (Fossacallista) exigua n.sp. Plate 13, figs. 10, 11.

Shell small, oval, much inflated, beaks not very prominent. Surface shining, with fine, regular, closely-set grooves becoming somewhat obsolete medially. Hinge like that of *opima*, except that the ligament is not quite so deeply set. Pallial sinus as in *opima*.

Holotype in Auckland Museum (ex Finlay Collection).

Length, 8.6 mm.; height, 6.2 mm.; inflation (1 valve), 2.5 mm.

Oligocene-Miocene: Aldinga (Janjikian).

This species differs from young *opima* of the same size in its more oval outline and less prominent beaks. The sculpture is much finer and more persistent than that of *opima*.

Notocallista (Fossacallista) tatei (Cossmann). Plate 14, figs. 1-3.

1887. *Cytherea tenuis* Tate, *Trans. R.S. Sth. Aust.*, vol. 9, p. 159, pl. 14, f. 16.

1920. *Callista Tatei* Cossmann, *Rev. crit. de Paléozool.*, vol. 24, p. 37, not *Cytherea tenuis* Hall and Meek, 1854.

The surface is smooth and shining over much of the disk, traversed by extremely fine, slightly irregular lines. The sculpture of concentric grooves about 6 per mm. is developed only for a short distance along the dorsal margin and near the lunule. In the left hinge the posterior cardinal is long and fairly strong, being faintly defined from the nymph, and the anterior lateral is high, slender and buttressed. In the right hinge the posterior cardinal is of moderate size, and the anterior lateral pit leads indirectly to the cardinal socket and a slightly undercut anterior cardinal. The ligament walls are only moderately high, and the ligament itself not very deeply sunk with reference to the left posterior marginal ridge. The pedal retractor is confluent with the anterior adductor, but the junction is somewhat constricted. The pallial sinus is broad at its mouth and rounded at the end with just a suggestion of truncation.

Oligocene-Miocene: Bird Rock Cliffs, Torquay (= Spring Creek), Victoria (F. A. Cudmore Collection).

Notocallista (Fossacallista) ancisa n.sp. Plate 14, figs. 11, 14.

Shell rather small, fragile, suboval; beaks rather prominent. Sculpture of fine concentric grooves 5 to 6 per mm. persisting across

the polished disk, but slightly irregular medially. Ligament deeply sunk below the right posterior marginal groove. Pedal retractor confluent. Pallial sinus with a wide mouth and a rounded end.

Holotype in Cudmore Collection.

Length, 21.6 mm.; height, 16.8 mm.; inflation (1 valve), 6 mm.

Oligocene-Miocene: Grice's Creek, Frankston, Victoria (Balcambian).

This species is closely related to *tatei* (= *tenuis*) but differs in having persistent concentric sculpture, more deeply sunk ligament, and straighter, more steeply inclined lunular margin. In general appearance *N. ancisa* strongly resembles the New Zealand *N. watti*, differing only in having persistent sculpture across the disk.

Notocallista (Fossacallista) singletoni n.sp. Plate 14, figs. 15, 16.

Shell of moderate size, strongly built, broadly suboval; beaks broad and prominent, a faint radial depression traversing the posterior area. Sculpture of well-marked, persistent grooves, about 4 per mm., separating low, bevelled ridges. In hinge and other internal characters like *cudmorei*. The lunule is double, but the inner groove is somewhat irregular and probably had a pathological origin.

Holotype in Auckland Museum (ex Finlay Collection).

Length, 26 mm.; height, 21 mm.; inflation (1 valve), 7 mm.

Oligocene-Miocene: Table Cape (Janjukian). Mr Singleton, who has seen the holotype, says that it is almost certainly from the upper beds.

N. singletoni is distinguished from *N. ancisa* and *N. tatei* by its higher, more prominent beaks, its greater relative height, and its coarser, persistent sculpture. The ligament is perhaps slightly shallower than in *ancisa*, also the pallial sinus is a shade narrower, but these differences are probably not important.

This species is dedicated to Mr F. A. Singleton, Melbourne University, who supplied much of the Australian fossil material for this study, also helpful notes on the different specimens.

Genus COSTACALLISTA Palmer.

1926. *Pal. Amer.*, vol. 1, no. 5, pp. 73, 84.

Type (by original designation): *Venus erycina* Linné, Recent, Indo-Pacific.

Figured: Palmer, *op. cit.*, Pl. 15, figs. 17, 18, 21.

Costacallista hectori (Finlay and Marwick). Plate 10, figs. 13, 15.

1937. *Notocallista hectori* Fin. and Marw., *N.Z. Geol. Surv. Pal. Bull.*, 15, p. 101, pl. 14, figs. 11, 12, 16.

When described, this species was compared with the Parisian Eocene *Tivelina elegans* (Lamk.) and *T. baudoni* Cossman. These, together with *T. elegantula* (Desh.) and *distans* (Desh.), can well be classed as *Costacallista*, and *hectori*, having similar sculpture, may be included. Certainly the broad, concentric ridges of *hectori* separate it from any of the groups of *Notocallista* yet known.

Typical *Tivelina* (G.-type, *Cytherea tellinaria* Lamk.) is sub-triangular with a smaller pallial sinus and without strong sculpture. Jukes-Brown (1913, p. 342) has pointed out that Cossmann's *Tivelina* of the Iconographie Complète contains several different groups, among which he used *Callista* for *baudoni*, *elegans* and *elegantula*. The species *heberti* (Desh.) from the Cotentin Eocene is also strongly ridged and, like the other species mentioned, appears to differ from the type of *Costacallista* only in its small size.

Genus PITAR Römer.

1857. Krit. Untersuch. d. Art. d. Moll., *Venus*, p. 15.

Type (by monotypy): *Venus tumens* Gmelin, Recent, West Africa.

For reference to figure see above.

Subgenus HYPHANTOSOMA Dall.

1902. *Proc. U.S. Nat. Mus.*, vol. 20, p. 354.

Type (by original designation): *Cytherea carbasea* Guppy, Miocene, Jamaica.

Figured: Woodring, *Miocene Moll. Bowden*, Pelecypods. and Scaphopods, Pl. 20, figs. 15-19.

Pitar (Hyphantosoma) sculpturatus (Marshall). Plate 10, fig. 8, 11.

1918. *Macrocallista sculpturata* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 272, pl. 21, figs. 6, a.

1927. *Pitar (Hyphantosoma) sculpturatus* (Marsh.); Marwick, *Trans. N.Z. Inst.*, vol. 57, p. 594, figs. 74-76.

? Miocene: G.S. loc. 800, west slope of Puketoi Range opposite Ormondville.

Oligocene: Pakaurangi Point (Hutchinsonian).

The left hinge has not yet been seen, the four specimens known from Pakaurangi Point being right valves and the single one from loc. 800 a closed individual. The New Zealand species differs from the genotype, *carbaseus*, in having a somewhat wider right posterior cardinal and a longer groove leading to the anterior lateral pit, which is thus more distant from the cardinals. The ornamentation of *sculpturatus* is considerably weaker than that of *carbaseus*, being intermediate between this species and *opisthogrammatus* Dall. These differences, however, do not appear to have more than specific value, especially in view of the close agreement of the other characters, even to the confluence of the pedal retractor.

No satisfactory explanation has yet been put forward as to how this peculiarly sculptured West Indian group came to inhabit New Zealand seas during the Oligocene-Miocene, and the possibility of *sculpturatus* being a parallel development from the *Fossacallista* stock must be considered. No likely ancestors are known in New Zealand, but the greatly inflated *N. opima* from the Balcombian of Victoria, though smaller, has a similar shape and hinge. Its lateral pit, however, is close to the cardinals and, of course, it shows no trace of zig-zag sculpture. Consequently it presents no positive evidence that *sculpturatus* arose from this kind of shell.

Possibly the left valve of *sculpturatus*, when found, will supply additional evidence of origin. The left posterior cardinal of *carbaseus* is quite separate from the nymph and diverges noticeably from it with age. Corresponding to this, in the right valve, the posterior cardinal is narrow and more than its own width distant from the nymph. On the other hand, the right posterior cardinal of *sculpturatus* is relatively broad, and the space between it and the nymph is narrow. This suggests that the left posterior cardinal of *sculpturatus* is closely connected with the nymph and favours derivation from the *Fossacallista* stock. The right anterior hinge-plate of *carbaseus* is more excavated than that of *sculpturatus* and the lateral teeth are weaker; but, admittedly, the differences are not great, and it seems advisable to regard *sculpturatus* as a true *Hyphantosomia* until a definite case to the contrary is established.

In this connexion it should be remembered that New Zealand has a few other faunal contacts with the southern part of North America. Curiously enough, two outstanding examples are also Veneridæ, namely, *Chione* str. and *Protothaca*, to which stocks the New Zealand groups *Austrovenus* and *Tuangia* are closely related, neither being represented in Australia or the Old World.

Genus ROHEA nov.

Genotype: *Paradione* (*Notocallista*) *trigonalis* Marwick, Oligocene, New Zealand.

Shell rather small, suboval, with somewhat narrow, erect, prominent beaks. Surface shining, bearing fine concentric grooves which become irregular and obsolete medially. Hinge-plate broad, flat and solid anteriorly, right hinge with two long anterior cardinals, the anterior slightly stronger, posterior cardinal very short and narrow, bifid; anterior lateral pit distant from the cardinals by its own length and not connected with the anterior cardinal socket by any groove. The lateral teeth are short and raised to a sharp point. Left posterior cardinal separated from the nymph by a groove, anterior lateral not buttressed and with a deep pit ventrally. Ligament well sunk, with high walls. Pedal retractor separated from the adductor. Pallial sinus slightly ascending, tapering, roundly truncated.

The sunken ligament resembles that of *Fossacallista* and *Chionella*, but the arrangement of the teeth differs greatly, both from these as well as from any of the *Notocallista*, *Costacallista*, or *Pitar* groups. The long, straight, right anterior cardinals, distant anterior lateral, and unexcavated hinge-plate recall such genera as *Aphrodina* and *Callistina*, *Dosiniopsis* and *Marwickia*, but there are no posterior laterals as in the last two. The long left posterior cardinal, well separated from the nymph, agrees with *Aphrodina* and *Callistina*, and the right posterior cardinal is short and slender as in *Callistina*. Accordingly, if the hinge is to be taken as a guide, *Rohea* must be a descendant of the European Cretaceous stock typified by *C. plana* (Sowby.). The New Zealand Cretaceous *Tikia* Marw. has a short right anterior cardinal and the hinge-plate anteriorly is well excavated, the right lateral pit communicating with the anterior cardinal socket.

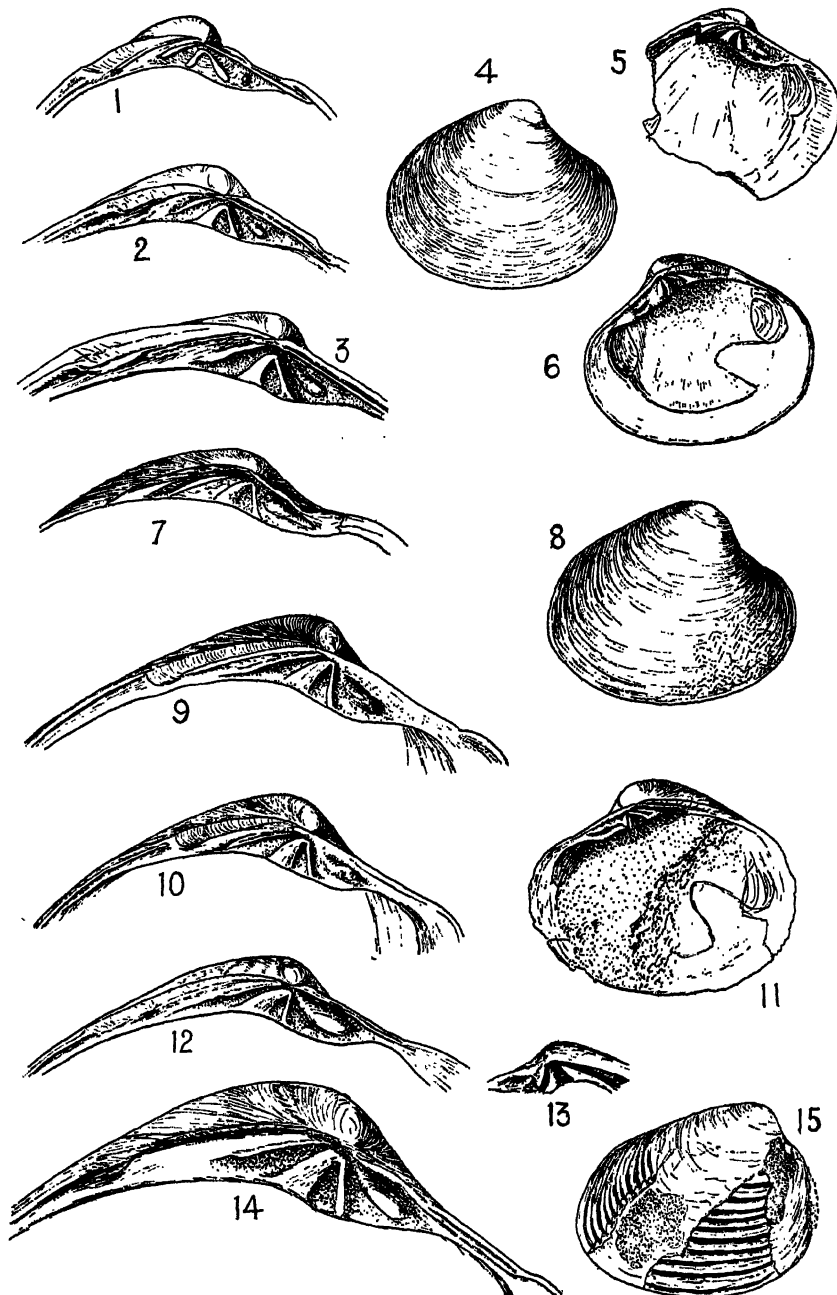
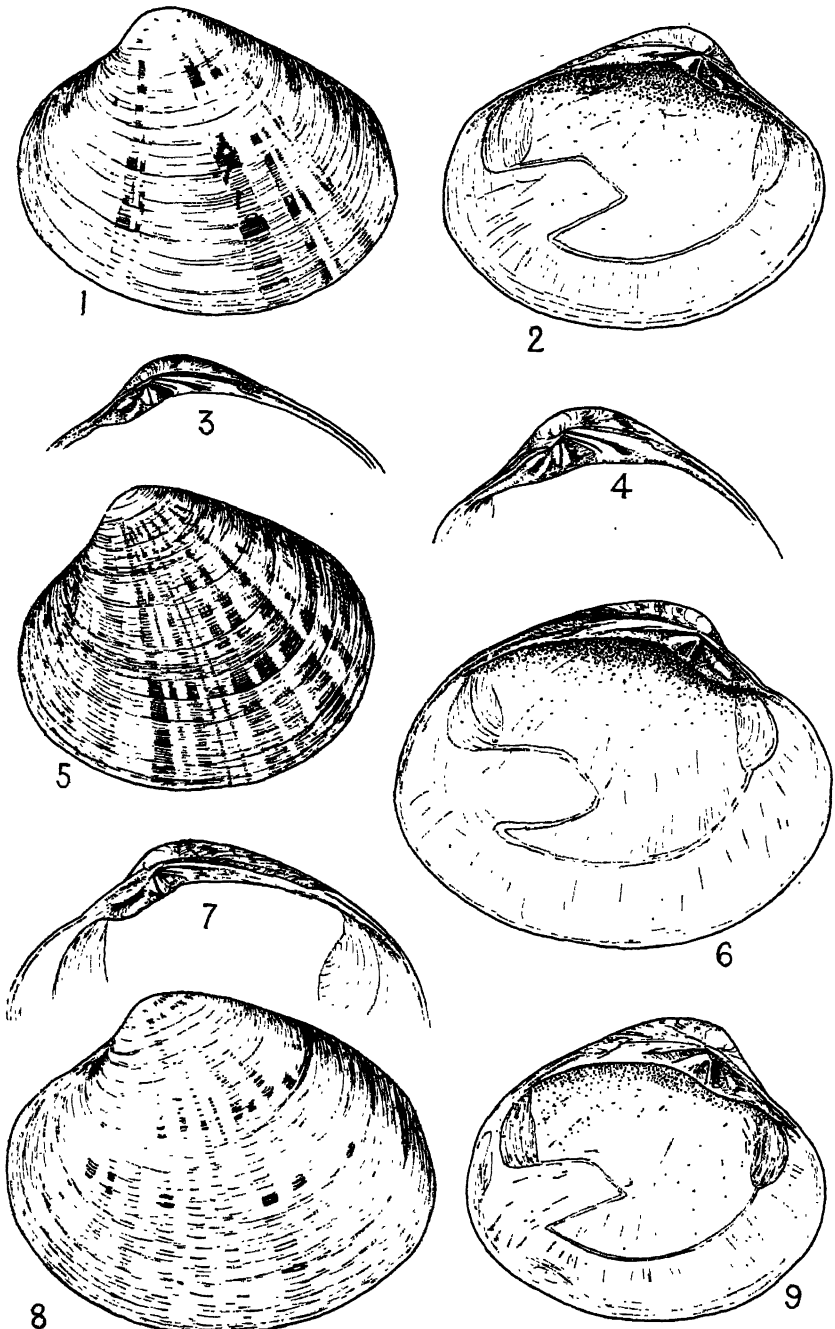
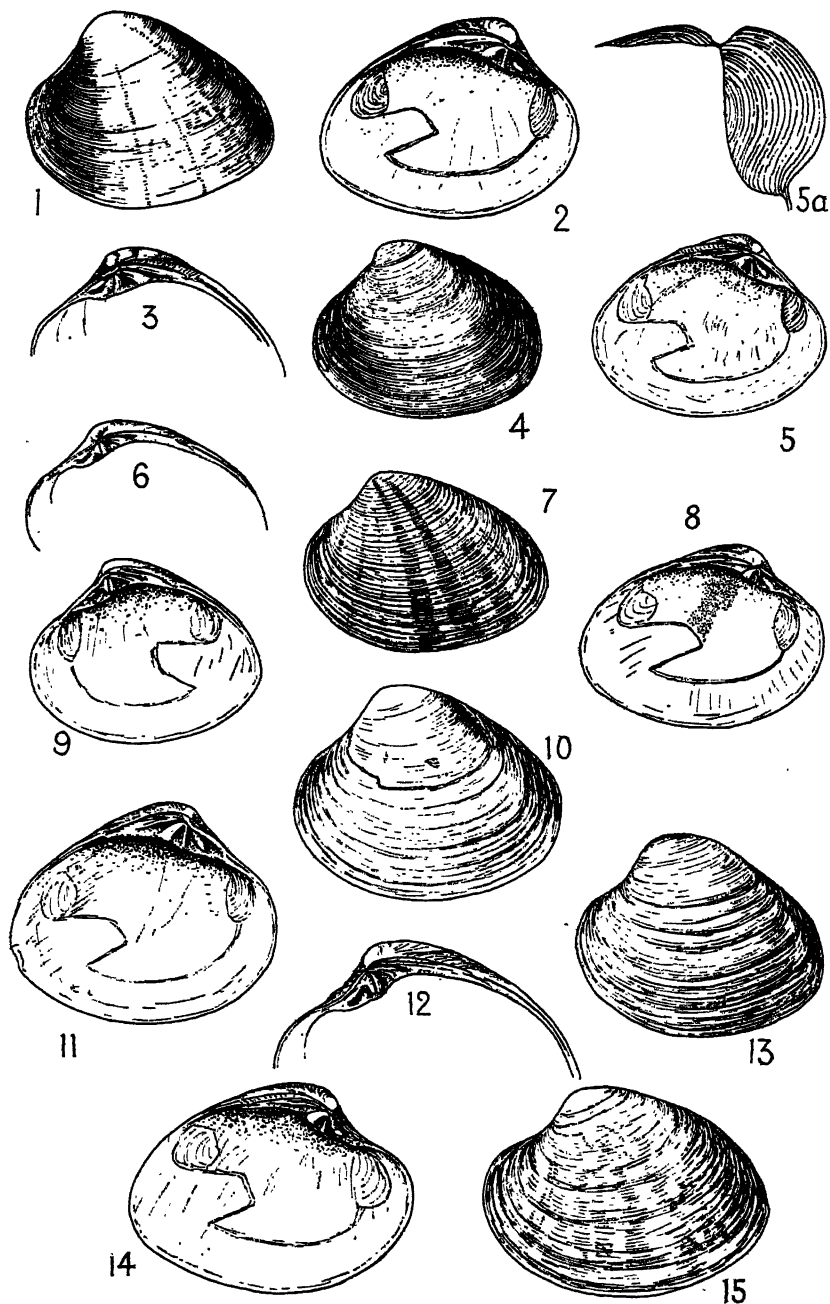


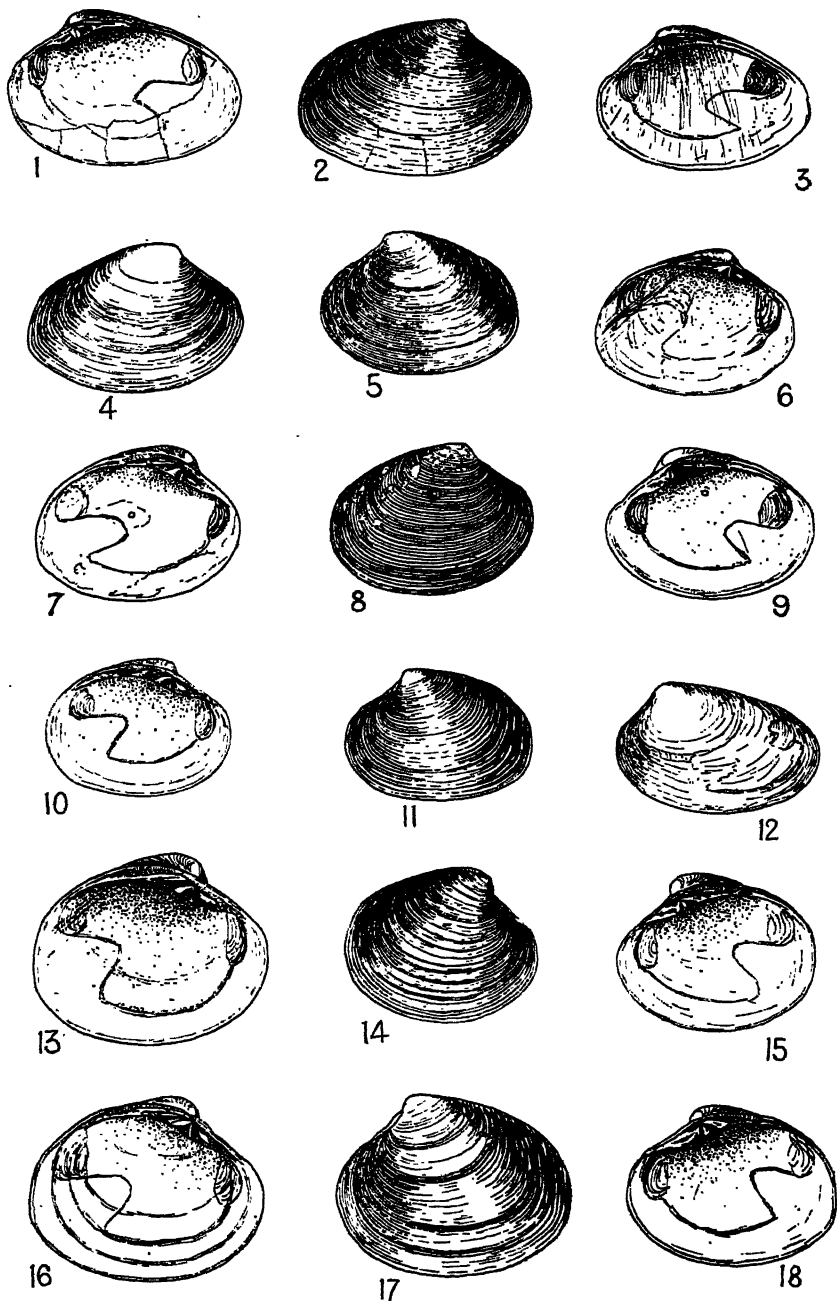
FIG. 1.—*Notocallista (Striacallista) multistriata* (Sowby.), juvenile, 2 mm. long, $\times 25$. FIG. 2.—*Ditto*, 3 mm. long, $\times 20$. Note larger anterior lateral. FIG. 3.—*Ditto*, 5.5 mm. long, $\times 12$. Anterior lateral buttressed. FIGS. 4-6.—*Rohea trigonalis* (Marw.), n.gen., topotypes, $\times 14$. FIG. 7.—*Tikia wilkeni* (Woods), Upper Cretac., Amuri Bluff, $\times 1$. FIGS. 8, 11.—*Pitar (Hyphantosoma) sculpturatus* (Marsh.), topotype, $\times 14$. FIG. 9.—*Chionella orolina* (Desh.), Paris Basin, $\times 3$. FIG. 10.—*Notocallista (Fossacallista) parki* (Marw.), holotype, $\times 3$. FIG. 12.—*Costacallista (Megapitaria) chione* (Linné), Malta, $\times 1$. FIGS. 13, 15.—*Costacallista hectori* (Fin. and Marw.), paratype and holotype, $\times 3$. FIG. 14.—*Notocallista kingi* (Gray).



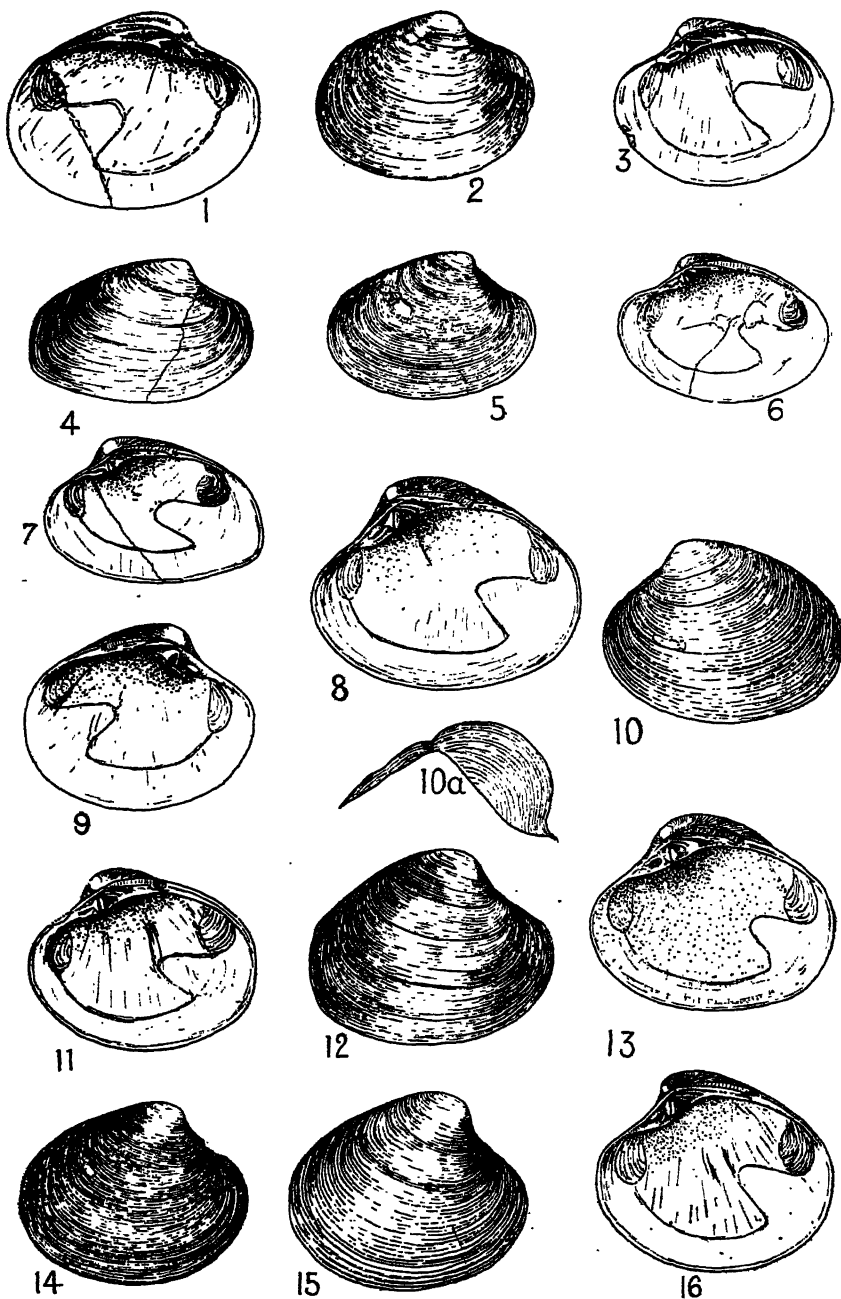
FIGS. 1-3.—*Notocallista kingi lamarchi* (Gray), Gulf of St. Vincent, $\times 1$. FIGS. 4, 5, 9.—*Notocallista kingi* (Gray), Twofold Bay, N.S.W., $\times 1$. FIGS. 6, 7, 8.—*Castacallista (Megapitaria) chione* (Linné), Malta, $\times 1$.



FIGS. 1-3.—*Notocallista* (*Striacallista*) *multistriata* (Sowby.), Stewart Is., $\times 1$.
 FIGS. 4-5.—*Notocallista* (*Striacallista*) *multistriata orolina* n. subsp., holotype, $\times 1$.
 FIG. 5a.—*N. multistriata orolina* n. subsp. Separate muscle scars of pedal retractor and anterior adductor. FIGS. 6-8.—*Notocallista* (*Striacallista*) *diemenensis* (Hanley), Tasmania, $\times 1$. FIG. 9.—*Notocallista* (*Striacallista*) *submultistriata* (Tate), McDonald's Muddy Creek, $\times 1$. FIGS. 10, 11.—*Ditto*, Jimmy's Pt., Kalimna, $\times 1$.
 FIG. 13.—*Ditto*, Jimmy's Pt., subtrigonal form, $\times 1$. FIGS. 12, 14, 15.—*Notocallista* (*Striacallista*) *disrupta* (Sowby.), Sydney Hbr., $\times 1$.



FIGS. 1, 2.—*Notocallista (Striacallista) cudmorei* n.sp., holotype, $\times 1\frac{1}{2}$. FIGS. 3, 4.—*Notocallista (Striacallista) pestis* n.sp., holotype, $\times 1$. FIGS. 5, 6.—*Notocallista (Striacallista) lutea* n.sp., holotype, $\times 2$. FIGS. 7–9.—*Notocallista (Striacallista) mollesta* n.sp., paratype and holotype, $\times 1$. FIGS. 10, 11.—*Notocallista (Fossacallista) exigua* n.sp., holotype, $\times 3$. FIG. 12.—*Notocallista (Fossacallista) makoensis* (Marw.), Ngahape Sim., $\times 2\frac{1}{2}$. FIG. 13.—*Notocallista (Fossacallista) opima* n.sp., paratype, $\times 3$. FIGS. 14, 15.—*Notocallista (Fossacallista) opima* n.sp., holotype, $\times 2$. FIGS. 16–18.—*Notocallista (Fossacallista) eburnea* (Tate), topotypes, $\times 2$.



FIGS. 1-3.—*Notocallista (Fossacallista) tatei* (Cossmann), Torquay, $\times 1$. FIGS. 4, 7.—*Notocallista (Fossacallista) tersa* n.sp., holotype, $\times 1\frac{1}{2}$. FIGS. 5, 6.—*Notocallista (Fossacallista) tecta* n.sp., holotype, $\times 1\frac{1}{2}$. FIG. 8.—*Notocallista (Fossacallista) parki* (Marw.), All Day Bay, $\times 1\frac{3}{5}$. FIGS. 9, 10.—*Notocallista (Fossacallista) parki* (Marw.), holotype, $\times 1\frac{3}{5}$. FIG. 10a.—*N. parki* (Marw.). Confluent muscle scars of pedal retractor and anterior adductor, $\times 5$. FIGS. 11, 14.—*Notocallista (Fossacallista) ancisa* n.sp., holotype, $\times 1\frac{1}{2}$. FIGS. 12, 13.—*Notocallista (Fossacallista) watti* n.sp., holotype, $\times 1$. FIGS. 15, 16.—*Notocallista (Fossacallista) singletoni* n.sp., holotype, $\times 1\frac{1}{2}$.

Rohea trigonalis (Marwick). Plate 10, figs. 4–6.

1927. *Paradione (Notocallista) trigonalis* Marw., *Trans. N.Z. Inst.*, vol. 57, p. 593, fig. 73.

Oligocene: Bed 6b, Clifden (Hutchinsonian).

Two topotypes in the Finlay Collection, a right and a fragmentary left valve, have been collected since the original was described. The left valve paratype described in 1927 and showing a hinge like that of *parki* came from a different horizon (band 7c) from the holotype and has a smaller lunule. It is not a *trigonalis* but a somewhat flattened *parki*.

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The Dykes of the Summit Road, Lyttelton.

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PART 1.—GENERAL.

THE construction of the Summit Pass Road around the northern and western rim of the Lyttelton caldera from Evans Pass at its eastern end to Gebbies Pass at its western end (see map) has revealed to view cross-sections of the various dykes which cut with radial orientation that sector of the volcanic cone. As 85 per cent. of the road has been excavated in the solid rock of the hillside, their number, thickness, internal structure, and relations to the country rock can be readily observed, and it would be unfortunate if advantage were not taken of the opportunity thus afforded to note any features these clear cross-sections may happen to show.

The distance measured around the crater-ring is 11 miles, but owing to deviations to obtain a fairly level grade the total length of the road under consideration is some 13 miles. The greater part lies between 1000 and 1500 feet above sea-level, and it is distant approximately three miles from the centre of the cone measured radially. As a rule the road follows round the external slope, but it occasionally passes along the inside for considerable distances. In general the dykes cut the road at right angles or nearly so, except where it passes round the shoulder of a spur, and they appear to radiate from a point a little south-west of Quail Island. It is unlikely, however, that the conduit up which the lava came to construct the cone itself was located at this spot. It probably lay in a somewhat excentric position near the reef which rises to just above sea-level from the floor of the harbour between the town of Lyttelton and Quail Island. As the dykes are almost certainly later than the main extrusions of lava, or at any rate mark an end phase, it is possible that the centre of vulcanicity shifted in a southerly direction during its later stages. Note that Akaroa is a later volcano than Lyttelton and its centre lies south-west of that of Lyttelton.

The counting and measurements hereafter recorded are only those of intrusions visible on the road. Massive dykes, exposed on the hillsides both above and below the road, are frequently reduced in size where they cross it or do not appear in proper alignment, so it was considered equitable to take the thickness only as it showed on the road, recognising that while some dykes would be recorded as smaller others in their turn would be larger. No direct reference will be made to the section of the crater-ring on the south-east side of the harbour, and in any case it could not furnish much of importance seeing that long stretches are masked completely by the later volcanics of Mount Herbert. In the parts not so covered there is evidence of the occurrence of a series of radial dykes of approximately the same number per unit length of the crater-ring and analogous in lithological character to those showing on the Summit Road on the northern side of the harbour.

A sequence might also be obtained by following the shore-platform that fringes the harbour, especially on the projecting points, but owing to obscurities it would be very incomplete and not comparable with that given by the road around the edge of the caldera. It should be mentioned here that the striking arrangement of the dykes round Lyttelton was noted by Haast, and he gave in his *Geology of Canterbury and Westland* (1879, pp. 333-43) a most picturesque description of those he was able to see on the hillsides, in quarries, on the shore-platform, and in the Lyttelton tunnel.

The occurrences on the road will be considered in 6 sections, the distances cited in connection with each being those measured round the rim of the caldera and not following the sinuosities of the road.

1. Evans Pass to Mount Pleasant Hostel, $1\frac{1}{2}$ miles.
2. Mount Pleasant Hostel to the Giant's Causeway, $2\frac{1}{2}$ miles.
3. Giant's Causeway to Dyer's Pass, 2 miles.
4. Dyer's Pass to Cass Peak, $2\frac{1}{2}$ miles.
5. Cass Peak to Coopers Knobs, $2\frac{1}{2}$ miles.
6. Coopers Knobs to the commencement of the greywacke ridge running N.W. from Gebbies Pass, $\frac{3}{4}$ mile.

Note.—These places will be found on the map.

On the first of these sections only 7 dykes are exposed, although considerable stretches of road are cut through the solid rock. Some may be obscured where the cuttings are in clay or loess, which occupy about one-third of the length of the road, but none were seen on the hillsides in the vicinity. The total combined thickness is 60 ft., which is 0.7 per cent. of the total distance between the end points of the section measured round the crater-ring. The dykes range up to 16 ft. in thickness, the largest being the olivine trachy-andesite which marks the summit of Evans Pass (Speight, 1923, pp. 134-5).

In the case of section 2 the road is cut in solid rock with the exception of a few chains, so that all or nearly all of the dykes have been exposed. They number 33, totalling 241 ft. in thickness, and so give an expansion of 1.9 per cent. Several are multiple. For example on the east side of Heathcote Valley there is a trachy-andesite dyke which runs almost parallel with the road, so that with the latter's sinuosities it is intersected three times. At the points where it shows furthest to the north-east it is green-grey or grey in colour and 15 ft. thick, but at the point furthest south it is 13 ft. thick, grey or brown in colour and bordered on the east side by 18 in. of basic rock and on the west side by a wedge-shaped mass 5-7 ft. thick (fig. 1). These fringing masses do not appear to have any close petrological relation to the main dyke, so that it must be described as a multiple and not a composite dyke. Although I could not determine the actual order of intrusion with certainty, it seemed reasonable to consider the basic dykes to be later than the main intrusion, especially as the fringing masses do not show alongside

the dyke where it cuts the road to the north-east. A similar feature is referred to later in the case of another multiple dyke, where the order of intrusion is definite.

A little further on is a 12 ft. dyke of basalt, and then a complex occurrence which presents some difficulty. On the east side there is first of all 7 ft. of andesite, reddish in colour, and jointed parallel to the walls of the dyke, but faulted and crushed, with inclusions of crush breccia; then 6 ft. of andesite showing little disturbance and with cross-jointing fairly well developed; this is succeeded by about 3 ft. 6 in. of country rock of wedge shape; and finally there is 6 ft. 6 in. of dark andesite with an interior zone showing porphyritic crystals of feldspar. This last also contains slickensided surfaces and gives evidence of movement. I think that this is one large dyke with an inclusion of country rock, but the suggestion is advanced with all diffidence.

There is other evidence of rock-movement in the locality and some of the less competent fragmentary beds show slickensided surfaces. These I consider to be due to movement within the beds themselves and not to change affecting the hillside as a whole, the phenomenon being analogous to the failure of unfaulted coal and the production of soft coal.

There is a large trachyte dyke (18 ft.) near the saddle where Bridle Track crosses (fig. 2). This appears to be thicker than 18 ft., but the discrepancy is due to a flange-like expansion of the dyke on the east side. Further on is the great dyke known as Castle Rock, which forms the backbone of the ridge bounding Heathcote Valley on the west. It does not appear on the road in proper alignment, for it takes a pronounced turn when approaching it and cuts the road as two dykes to the east of the ridge, with a possible splinter on the west side.

Section 3 extends from the great dyke at the head of Raupaki Valley known as the Giant's Causeway to Dyer's Pass. It contains several large dykes including the Causeway itself (35 ft.). This is a trachyte and stands up as a great wall, and so has little resemblance to the classic occurrence in the north of Ireland. Considerable lengths of this part of the road cut in solid rock show few or no dykes, and this is specially the case where massive flows of andesite have to be broken through, such as those which occur north of Trig. AA, and on the northern slope of the Sugarloaf. In connection with this it is to be generally noted that, with some striking exceptions, dykes are more common on the saddles and less common on the ridges which mark the edge of the crater-ring. It may be that the harder rock has determined the position of the radial ridges and intrusions found this difficult of penetration, or perhaps that the saddles with their numerous dykes were more susceptible to weathering and were therefore more rapidly reduced.

A large hornblende trachy-andesite dyke greenish grey in colour on the margins and brownish grey in the interior occurs west of Trig. AA, and a large dyke (25 ft.), a little further on along the road, has margins 10 ft. and 8 ft. thick with an internal core of

basalt 7 ft. thick, the basalt being apparently the later intrusion. Another trachy-andesite dyke (15 ft.), just east of the Sugarloaf ridge, is interesting for containing inclusions of hornblende diorite up to 12 in. in length as well as of hornblende as aggregations and in individual crystals, a striking instance of the association of large hornblendes with rocks of this class. Some of the dykes have an internal zone, brown in colour, and speckly with feldspars, with a much finer grained dark margin.

Thirty-six dykes were measured in this section, having an aggregate thickness of 220 ft., which gives an expansion of the cone resulting from their intrusion of 2.1 per cent.

Section 4 from Dyer's Pass to Cass Peak has 76 dykes with a total thickness of 398 ft., indicating an expansion of 3.3 per cent. This is lower than the real value since the road is cut in clay or loess for considerable distances and intrusions, if existent, do not show. The visible ones range up to 39 ft. in thickness. This section is remarkable for the occurrence of large dykes of trachytoid character. The first to be encountered is about half a mile from Dyer's Pass. It is an excellent example of a multiple dyke. Before the road was widened the following succession was to be seen at this point:—

- i. Trachy-andesite, 4 ft.
- ii. Country rock, 1 ft.
- iii. Trachyte, main mass, 24 ft.
- iv. Basic andesite of variable thickness, 12 in. up to 2 ft.
- v. Trachyte, same as iii, 7 ft.
- vi. Basic andesite, same as iv, 3 ft., but wedge-shaped, with point upward.
- vii. Trachyte, 3 ft.
- viii. Basic andesite, same as iv, 3 ft., wedge-shaped, with point downward.
- ix. Trachyte, 3 ft. This has a glassy margin welded into the country rock.

In this section the repetition of vi and viii is clearly due to faulting, as the slickensided surfaces show. The strike of this fault is almost parallel to that of the dyke, but in this case the faulting is post-intrusion, so that it can hardly have been responsible for the intrusion unless the present fault marks the reopening of an old fissure. As a result of the widening of the road the section has become different. No. ii has thinned out till its maximum thickness is only 6 in.; iv shows as before; v has thickened to 9 ft.; and there are no wedge-shaped masses of andesite (vi and viii) in this part but one intrusion 2 ft. 9 in. thick. The zone of platy jointing in the trachyte on the east side is still 8 ft. thick, but on the west side owing to repetition due to faulting it now shows a total of 12 ft., with the andesite 2 ft. 9 in. intruded parallel to the jointing (fig. 3). In the quarry a chain or so south-east, and off the road, this andesite does not show.

The order of succession in this dyke is that the andesite was intruded after the trachyte had been consolidated. On both sides the trachyte exhibits a marginal facies with platy jointing and an interior zone with columnar cross jointing, and the intrusion has followed up the plane of weakness at the contact of the two types. The fact that the junction of the two types is a plane of weakness is well exemplified by the basaltic dyke which lies about four yards to the east of this dyke. It is of variable thickness, but averages about 4 ft., with an internal zone of cross jointing, and the contact between this and the outside platy jointing definitely fluted on both sides, and also the fluting is repeated at varying distances from the margin of the dyke within the zone of the platy facies. This indicates some movement of the middle zone while the exterior was relatively stable and the rock was sufficiently hard to retain markings impressed on it. The surfaces are not polished in any way, so the rock was not quite solid, but probably in a viscous condition. The fact that successive plates of the external zone are also fluted upon themselves suggests that platy jointing may be partly due to flow and not entirely attributable to chilling and consequent contraction of successive layers of cooling rock.

Similar features were noted in basaltic dykes elsewhere round the road, and they are apparently analogous to the occurrence near Auckland noted by Bartrum (1928, pp. 23-5), and to the horizontal flutings in dykes in the Hopi country, Arizona, as recorded by Howel Williams (1936, pp. 121-2).

The large Hoonhay trachy-andesite dyke is cut by the road some 20 chains further on. Where quarried above the road it is 19 ft. thick, but on the road this is reduced to 14 ft. This dyke is one of the most persistent to be noted in the district, as it can be traced for three miles down the outer slope of the cone till its possible further extension is masked by the gravels of the Canterbury Plains.

Further on there are several multiple dykes, a notable one showing on the road as it passes round the spur leading up to Mt. Ada. This shows the following sequence in order from north to south:—(i) trachyte, 11 ft.; (ii) country rock, 6 in.; (iii) trachyte, 7 ft., with inclusions of country rock; (iv) country rock, 18 in.; (v) trachyte, 7 ft. It is not clear whether the inclusions of country rock, which are wedge-shaped, are due to faulting or whether they are masses caught up during intrusion, or yet again whether they have been isolated from their parent rock by the splitting of the intrusion.

A little further on down the cutting is a basaltic dyke (5 ft.), then after a short interval comes a very large greenish trachyte (39 ft.), which is similar in mineral composition to the large dyke quarried many years ago for building stone at various points below the road to the west. Although this has a thickness in places of 60 ft. lower down the hill it does not appear on the road where it should do so. They are both trachytes with soda-amphibole in addition to the soda-pyroxene, and they both contain inclusions of the andesite country rock. It is clear that the fissure up which the dyke

material came was not continuous, but sent off a splinter from the main direction; a clear case of side-stepping. Reaching down the ridge from Cass Peak is a fairly large dyke (10 ft.) of apparently related character, but it is much more basic in composition, although it may have been injected at the same time.

The dominant material of the dykes of this section is trachytoid; basaltic dykes are usually small, though they are perhaps more numerous than the more acid variety.

Section 5, stretching from Cass Peak to Coopers Knobs, includes about one-third of cutting in loess or clay with consequent obscurity. However, 26 dykes were measured, having a total thickness of 137 ft., which gives an expansion of 1.4 per cent. If all of the dykes could be seen, it would be much higher, probably over 2 per cent. The material is mostly trachytic, and none of the dykes are large, the largest being only 12 ft. in thickness; at least one of them is multiple.

In section 6 the road follows the inside of the crater-ring and gradually falls from 1500 ft. to about 800 ft., where it meets the rhyolite and greywacke of the Gebbies Pass ridge. It has been cut in solid rock almost continuously for approximately three-quarters of a mile, so that the sequence of dykes is reasonably complete. Altogether 41 were counted, 30 of these being in the upper part of the road, with a definite falling off in number as the road becomes lower in level, a point to be noticed seeing that this part of the road is nearer the internal base of the cone where more intrusions are to be expected.

The largest dyke measured in this section was 16 ft. in thickness; one or two multiple dykes were seen; they are mostly basaltic. The total thickness is 177 ft., giving an expansion of 3.2 per cent. This high value can be plausibly explained by the fact that the road is here at a lower level than in other parts of the crater-ring and dykes which could not reach the upper levels have been cut by the road, but this cannot be maintained for certainty since they are relatively infrequent in the lower parts of the road, and, further, there is a tendency all round the crater-ring for the dykes to be bunched in certain sectors. Although dykes do occur in the greywacke and rhyolite overlying it further along the road towards the summit of Gebbies Pass, they were not considered in this examination since their circumstances are somewhat different in that they do not belong to the cone itself as they show at present.

To summarise, the number of dykes cut by the road and measured totals 220, with a combined thickness of 1233 ft., giving an expansion of the cone corresponding to road level of 2.13 per cent., an amount which is of the same order as that given by each section indicated previously. Allowing for parts of the road which are obscure, the total expansion of this height of the cone is not likely to exceed 2.5 per cent., but it will be in the vicinity of that amount. There is not definite evidence available for the expansion of the cone at lower levels, but it will certainly be greater nearer to the centre of eruption and considerably less for those portions of the periphery at lower levels.

The only records with which I can compare this amount of expansion are those given in the case of the dykes of the islands of Arran and Mull on the west coast of Scotland, and these are not analogous in that they deal with parallel dykes and not those radial to a cone. The value in the case of the former is 7.1 per cent. over a breadth of 14.8 miles, and in the case of the latter 3.8 per cent. over a breadth of 12.5 miles. Of course, it is possible in both cases that the crustal adjustments necessary for these intrusions have taken effect over a greater breadth than that where the dykes are actually located, and for comparative purposes the percentages are perhaps to be slightly reduced, whereas in the Lyttelton case the circuit is a closed one; and, further, owing to the presence of obscurities the value given is a minimum one. It should be mentioned, too, that the number of dykes on the south side of Quail Island necessitates a much higher expansion, estimated from 5 to 10 per cent., perhaps more, but this affects only a limited area of the floor of the caldera.

I have not been able to compare the conditions of Lyttelton with those of any other volcanic cone with the exception of Vesuvius and Etna. In the case of the former the dykes are irregular in orientation, whereas in the case of Lyttelton, with the exception of the dykes near the centre of intrusion, they are quite radial. In the case of Etna, Lyell mentions radial dykes, and the statement is amplified by Geikie, but sets of parallel dykes are mentioned as well, so that the case is not quite analogous. The only occurrence in Great Britain which might be cited is the island of Rùm with its beautiful arrangement of radial dykes, but the sequence includes plutonic rocks of various types and the island is not a simple volcanic cone. In the case of the island of Mull the structure is complex, with cone-sheets, ring-dykes, and a parallel arrangement of ordinary dykes, although in some cases there may be an approach to radial orientation.

In America, too, the only cases recorded to date that I am aware of which might be considered in this connection are those of the Spanish Peaks, the Shiprock in the Navajo volcanic field, and the Highwood Mountains. The first of these is a deeply eroded double stock with plutonic rocks (Knopf, 1936), the second a volcanic neck with a small number of radiating dykes (Howell Williams, 1936), and the last, according to a private communication from Professor Daly of Harvard University, a complex assemblage of dykes round a number of centres of eruption including at least one laccolite. They are thus not analogous to the case under consideration.

The general explanation of the mode of formation of volcanic dykes as given by Barrell, Iddings, Daly, and others is that they result from fissure formation following on stresses in the cone, and that these fissures have been filled with liquid material injected from below, or laterally by hydrostatic or other pressure from the central crater cavity or from some reservoir beneath the mountain. No completely demonstrable explanation has been advanced to account for the regular orientation, though suggestions have been made of its association with (1) faulting on radial lines, (2) pre-existing

major fault fissures, (3) fissuring on radial lines, (4) that the magma has just made its own way. A corollary to any of these modes of formation is the suggestion made by Barrell, Daly, and others that the injection took place rapidly, for if it had been slow the magma would have cooled and so lost mobility.

There is no evidence available from Lyttelton which indicates the presence of major faults or faulting on radial lines prior to intrusion. Although faulting is associated with a few of the dykes the movements have taken place subsequent to intrusion. The dykes occasionally show local irregularities in direction while preserving their general orientation, and the inclusion not only of small pieces, but of large masses, of country rock are both features which support the contention that they are associated with fissures and not with faults, and the latter observation suggests that the formation of the fissure and the intrusion of the dyke material were synchronous. The side-stepping of dykes and local irregularities in direction seem to indicate that the dykes themselves largely determine the formation of fissures through which the liquid material has been forced.

An expansion of the crust amounting to nearly 2.5 per cent. suggests that dykes may be located on tension ruptures, but the intrusion of the material from some crateral or sub-crateral cavity under internal strains may be responsible for the fissures as well as for their subsequent or simultaneous injection. It is well known that doming up of a volcanic cone is a common precedent to eruption, and this must cause tension in the mountain. From this arises, therefore, the force responsible for the fissuring and probable synchronous injection. It may be considered as certain that an expansion of the cone took place on many occasions during the period of active vulcanicity, but it is also likely that bunches of dykes with similar or related composition were formed synchronously in a limited sector of the cone, so that it would follow that the number of injection periods might be considerably less than the number of dykes, and may indeed have been only a small fraction of the number.

One point should be noted, viz., that the orientation of the dominant joints in the lava flows is the same as the strike of the dykes. These joints are no doubt due to the formation of tension ruptures accompanying shrinkage on cooling, and this will take place chiefly from the sides of the flows, and as they are generally radial so will the dominant joints be radial too; it is of course recognised that there will be joints with other orientation. But the dominant radial joints provide planes of weakness which may have some effect in directing the paths of intrusions. It is clear that joints do so operate in the case of multiple dykes as noted earlier, and instances were seen where the direction of single dykes coincided with that of dominant radial jointing in closely adjacent rocks, especially when the flows are massive and naturally somewhat resistant to intrusions. These cases may after all be chance coincidences.

The position of the locus of the origin of injection must have been at some depth, and not a mere surface crateral manifestation, for the material of the dykes is not directly related to that of the

cone. The occurrence among the dykes of olivine-augite-andesite (i.e., feldspar basalt) with large and numerous phenocrysts of labradorite and oligoclase-andesine groundmass is extremely rare, although this is the dominant lava of the cone. Basic andesites do occur, but they are not as a rule of this type. Some of the basaltic dykes may be related to the later outpourings of basalt, but the great mass of trachytoid composition so characteristic of the intrusions is not represented in the extruded material. This implies that the depth from which injection took place must be such that differentiation is on a somewhat large scale and also reasonably complete, and this points to sub-crustal reservoirs below the surface as the source of the material. What is responsible for the initiation of this movement cannot be indicated till the whole mechanism of volcanic eruption has been ascertained.

It should be noted that the adjacent cone of Akaroa exhibits a similar series of radiating dykes, but judging from the paucity of outcrop of upstanding dykes and also of exposures in road cuttings, the series is hardly comparable with that of Lyttelton, although the shore-platforms in the central portion of the harbour and in the vicinity of Onawe do show an analogous development, and the number of intrusions near Onawe is almost, if not quite, equal to that of the complex to the south of Quail Island, this being the counterpart in Lyttelton of the peninsula of Onawe in Akaroa Harbour.

PART 2.—PETROGRAPHY.

The petrography of the dykes has already been dealt with to some extent by the present author (Speight, 1923, pp. 128-146) and analyses of a number have been given with a description of their general petrographical features. In this article the work is extended and the author must express his thanks and admiration to the Dominion Laboratory for the excellent analyses they have furnished.

Although there is general gradation between rocks lying at the ends of the trachyte to basalt series, yet certain types are more than ordinarily important and may be indicated as follows:—

1. Greenish trachyte, with phenocrysts of sanidine and microphenocrysts of soda-amphibole in a base of sanidine laths, aegirine-augite grains, and a little quartz. This is the most acid type.
2. Trachyte, brownish, pinkish, or grey-green in colour, with base composed of
 - i. stumpy sanidine and possibly anorthoclase-microlites with grains of aegirine-augite, and,
 - ii. long laths of sanidine and possibly anorthoclase showing either flow arrangement or laths in bundles of radiating sheaf-like forms,

both types containing phenocrysts of sanidine, andesine, or oligoclase-andesine, sometimes anorthoclase, phenocrysts of aegirine-augite, at times with microphenocrysts of the same mineral, occasional brownish hornblende, and very occasional olivine; tridymite occurs sparingly.

3. More basic trachytes, with light green-grey or deep green colour containing few phenocrysts.
4. Trachy-andesites, greenish or greyish in colour, frequently with brown hornblende and olivine.
5. Andesites, basic in character, and grading into 6.
6. Basalts, some acid and others very basic; in some of the basic forms hornblende is a notable constituent, and they appear to have some relation to the trachytes.

The hornblende is perhaps the most striking mineral in these rocks. It first of all occurs as large brownish or brownish green crystals and aggregations, the crystals ranging up to 10 cm. in length, but usually less than 1 cm.; they are sometimes unaltered, but occasionally are resorbed partially or completely. Another type of amphibole is a soda variety resembling arfvedsonite, which occurs sparingly as micro-phenocrysts in some of the more alkaline types. The augite which is most common is a greenish, slightly pleochroic aegirine-augite which occurs as phenocrysts, microphenocrysts, or disseminated through the base as grains and in stumpy crystal forms. A greyish, slightly purple, not appreciably pleochroic augite also occurs in subordinate amount. The olivine is sometimes unaltered but usually stained with iron oxides along cracks and marginally, and occasionally it is entirely replaced by iddingsite.

The feldspars are usually of the acid type, basic forms occurring only in the basic andesites and basalts. They frequently show zonal structure and denticulate margins, the last feature being specially characteristic of the base of the more acid rocks. Some of these denticulate feldspar laths have a lower index of refraction than balsam and may therefore be anorthoclase especially in the sodic rocks, but in other cases the index is higher than that of balsam and the minerals must be oligoclase or andesine, most likely the former.

It has not been found possible to section all the dykes, but fifty have been examined microscopically, and to the best of my knowledge no important type has been omitted. I quote the analyses kindly supplied by the Dominion Laboratory, and none previously published are listed here, but all that have appeared to date are quoted by the present author (*loc. cit.*, pp. 130-1) in his paper on the Intrusive Rocks of Banks Peninsula. These recent analyses furnish a useful supplement to the list there given.

A perusal of the list given herewith indicates the presence of trachytoid rocks with a moderately high percentage of soda, which is accounted for by the presence of oligoclase and andesine and by aegirine-augite. The basic rocks do not show any special abnormality in composition, except a fairly high percentage of titanium. The water content of the specimens submitted is very high considering that all were obtained from rock cuttings and every care was taken to get as fresh a sample as possible; in some cases some amount of decomposition appeared to be inherent in the rocks as if it contained some percentages of unstable mineral.

Analyses.

Analyst, F. T. Seelye.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
SiO ₂	65.41	56.07	53.66	50.12	49.62	47.82	47.91
Al ₂ O ₃	14.25	18.16	16.01	15.04	14.95	15.60	14.64
Fe ₂ O ₃	5.00	3.60	7.09	6.69	5.13	5.24	2.91
FeO	0.51	3.37	2.30	3.61	6.66	8.28	8.25
MgO	0.56	1.20	1.73	2.39	3.78	4.08	6.99
CaO	1.57	2.64	4.43	6.65	7.57	8.60	9.09
Na ₂ O	4.14	5.38	5.29	3.22	4.04	3.38	3.03
K ₂ O	4.18	3.75	2.56	1.44	1.46	0.98	1.16
Water lost above 105° C.	1.00	1.79	1.38	2.32	1.14	0.44	1.45
Water lost below 105° C.	2.54	2.22	3.12	4.98	1.96	1.22	0.92
CO ₂	trace	nt. fd.	nt. fd.	trace	nt. fd.	trace	trace
TiO ₂	0.52	1.24	1.63	2.37	2.88	3.41	2.68
P ₂ O ₅	0.15	0.38	0.64	0.89	0.78	0.53	0.48
S	0.01	0.01	0.01	0.02	0.04	0.01	0.03
MnO	0.04	0.13	0.13	0.17	0.15	0.16	0.18
NiO	nt. fd.	nt. fd.	nt. fd.	0.01	0.01	0.03	0.02
BaO	0.10	0.09	0.11	0.08	0.04	0.05	0.04
SrO*	0.02	0.02	0.05	0.05	0.07	0.07	0.05
ZrO ₂	0.06	nt. fd.	trace	nt. fd.	nt. fd.	nt. fd.	nt. fd.
Cr ₂ O ₃	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.	nt. fd.	0.05
Cl	nt. fd.	nt. fd.	nt. fd.	trace	nt. fd.	nt. fd.	nt. fd.
Totals	100.06	100.05	100.14	100.05	100.28	99.90	99.88

* Amount of SrO determined spectrographically in the CaO by S. H. Wilson.

C.I.P.W. Norms and Symbols.

Q	21.58	3.44	4.01	11.66	2.33	2.06	
or	24.71	22.15	15.14	8.51	8.62	5.79	6.84
ab	35.02	45.51	44.72	27.21	34.18	28.57	25.64
an	6.76	10.60	12.41	22.33	18.36	24.51	22.92
C	0.44	1.37					
di			4.20	3.75	11.34	11.97	15.40
hy	1.40	4.39	2.36	4.22	7.48	9.89	9.51
ol							6.59
mt	0.28	5.23	3.10	5.33	7.43	7.59	4.22
il	0.99	2.35	3.10	4.50	5.48	6.48	5.08
hm	4.80		4.95	3.01			
ap	0.37	0.91	1.52	2.12	1.85	1.25	1.15

No. 1. Trachyte, Dyer's Pass ridge, I". 4. "2. 3.(4), Toscanose.

No. 2. Trachyte, Cass Peak, (I).II. 5. 2. "4., Akerose

No. 3. Soda Trachy-Andesite, Dyer's Pass ridge, II. 5. 2. 4., Akerose.

No. 4. Basic Andesite, occurring as an intrusion in No. 1., Dyer's Pass ridge, II. 4". 3. 4., Tonalose.

No. 5. Basalt, Mt. Ada, II(III). 5. 3. 4., Andose.

No. 6. Feldspar Basalt, near Hoonhay Dyke, (II)III. 5. 3". 4", Camptonose.

No. 7. Dolerite. 4th dyke down cutting from Coopers Knobs, "III. 5. 3". 4., Camptonose.

Normal Trachytes.

The most acid trachyte encountered is the soda-amphibole trachyte of Kennedy's Bush (Speight, 1908, p. 176), and it should be noted that this rock contains a considerable amount of soda-augite in addition to the micro-phenocrysts of the amphibole.

The most common type of trachyte is brown in colour, and there is also a frequent occurrence of a stain of oxide of iron which occasionally appears to be developed along spheroidal cracks and ordinary joints. A typical example is the large dyke (fig. 3) on the summit of the Dyer's Pass ridge. Crystals of feldspar show plainly in the hand specimen, and under the microscope they prove to be andesine with very occasional sanidine. The base is composed of short stumpy laths of sanidine, and there are as well a fair number of forms with denticulate margin and nearly straight extinction, both forms having a lower index of refraction than balsam, so anorthoclase is probably present in addition to sanidine. In between the laths are numerous grains of magnetite, some of which are no doubt derived from the augite. Towards the margin of the dyke the texture of the base becomes progressively finer, and this applies to the part with platy jointing, while at the margin of the dyke there is a selvage which is definitely glassy. In this facies the feldspar phenocrysts become more numerous and are apparently entirely of andesine; greenish crystals of aegirine-augite also occur, and the glass has developed well-defined perlitic cracks. This facies is the chilled margin of the mass and the increased proportion of phenocrysts is noteworthy. Analysis No. 1 is from this dyke. This is similar in all respects with the analysis of a dyke from Heathcote also cutting the Summit Road (Speight, 1923, pp. 130-1). I have little further comment to make on this rock except that the slides of specimens taken from the summit of the ridge show very little hornblende, no mica, and much more aegirine-augite as phenocrysts and microphenocrysts, and also there is an approach to a bostonitic habit in the base (fig. 5).

The intersection of Castle Rock, the large dyke that forms the crest of the ridge on the western side of Heathcote Valley, shows variations which are characteristic of the main dyke. First of all the interior is definitely trachytic, the feldspars being chiefly sanidine and occasional andesine; the microphenocrysts are of aegirine-augite; and the base of long laths of feldspar showing flow structure and also radiating sheaf-like forms (fig. 6), among which are small grains of greenish grey augite and magnetite. The feldspars have lower index of refraction than balsam and most of them show straight extinction, but there are a number which have an angle of extinction for albite, so in all probability both are present.

In a 6 ft. splinter of this dyke the features are similar except that the augite phenocrysts are definitely purplish, and olivine occurs unaltered and again replaced at times by iddingsite. The base is composed of microlites, some with straight edges and others with denticulate margins both with index less than balsam and with extinction angles of sanidine and albite. The texture is definitely bostonitic and it is probable that anorthoclase is present as well;

there are also frequent patches of tridymite. As noted previously (*loc. cit.*, pp. 136-8) this dyke is very variable in character both along the strike and across it.

The type of trachyte mentioned first occurs as dykes at Giants Causeway, further west near the 4 mile post, on the eastern side of the Sugarloaf, on the ridge leading up to Mt. Ada, and elsewhere.

Basic Trachytes.

In addition to these normal trachytes there are others more basic in character, and it is possible that they might be assigned to the trachy-andesites, andesine occurring as phenocrysts more commonly than sanidine. These rocks are usually grey or greenish grey in colour, an excellent example being that quarried on the north side of the road passing over the shoulder of the spur leading up to Cass Peak. This is very vesicular, sometimes showing in the hand specimen white crystals of feldspar and very occasionally small crystals of hornblende and also olivine. Under the microscope it shows phenocrysts of andesine and microphenocrysts of sanidine. The base is holocrystalline and consists chiefly of feldspar laths from .3 to .4 mm. in length, some with straight edges and others markedly denticulate; the index of refraction of some of the laths is about that of balsam, some a little lower, and the angle of extinction measured with the length is generally straight or nearly so, but some of the laths are twinned and show an extinction angle, which with the index of refraction just below balsam shows them to be albite-oligoclase. The untwinned laths show straight extinction and are no doubt sanidine, but the denticulated margins suggest the presence of anorthoclase, though it was not determined for certain (fig. 7). In between the laths are numerous short crystals and laths of aegirine-augite, green-grey in colour and frequently stained with decomposition products of iron-oxide. Neither hornblende nor olivine appeared in any of the slides made. The chemical composition of this rock is given in analysis No. 2, which shows that it has a fairly high percentage of alkalis with dominant soda and a moderate amount of lime, which is in keeping with the absence of a basic feldspar. Composition, mineral content, and texture therefore indicate that the rock should be called a trachyte. It should be noted that the high percentage of water shown in these analyses reduces considerably the importance of other constituents in the percentage composition. The dyke which occurs just east of the main trachyte dyke on Dyer's Pass ridge (fig. 3b) might possibly be placed in this category, but the composition is definitely more basic, and it will be best to assign it to next section.

Trachy-andesites.

The rock just referred to belongs here. It occurs just east of the large trachyte dyke on Dyer's Pass ridge referred to earlier, marked b in fig. 3. In the hand specimen it is dark grey in colour but with a suggestion of very dark green as it occurs in the road cutting. On the joint surfaces it shows brown owing to a stain of iron oxide. It is generally slightly vesicular and in parts markedly so. Under the microscope it appears to be composed chiefly of

prismoids of feldspar with denticulate margins and of lengths from .3 to .4 mm., and with index of refraction slightly higher than that of balsam. The extinction angle is very low, so they must be oligoclase, with probably more acid outgrowths, the whole texture being strongly reminiscent of bostonite (fig. 8). Some few of the prisms of the base have an index of refraction lower than that of balsam and with approximately straight extinction, so some sanidine or anorthoclase is probably present. In between the feldspar laths are small grains and stumpy crystals of aegirine-augite, sometimes stained brown with oxide of iron, and there are grains of magnetite as well as some brownish alteration product. In this base are very occasional microphenocrysts of feldspar with refractive index higher than balsam, an extinction angle, as observed, of andesine, but the feldspar may really be more basic. The chemical composition of the rock is given in analysis No. 3. The importance of soda as compared with potash and the high percentage of water are the two most striking features. The former is reflected by the amount of albite in the norm, and the lime is reflected in the amount of anorthite. The rock has certain relations to andesite on account of the oligoclase in the base, and to trachyte by the presence of the more acid feldspar, even if in small amount. There is a close resemblance in composition to other undoubted trachy-andesites of the area, such as those at Evans Pass, Castle Rock, and Hoonhay (see Speight, *loc. cit.* pp. 130-1), and the group is extremely well represented. They are usually rocks of light colour, grey or greenish grey, as a rule, and show freely crystals of hornblende which reach 1 cm. in length, though they are usually less. Under the microscope the phenocrysts are hornblende, augite, plagioclase, olivine in that order of importance, the plagioclase being either andesine or labradorite. The hornblende is brown with a faint tinge of green, at times resorbed on the margins; the augite is grey and then again faint purplish in colour, the olivine fresh or altered to iddingsite, either as crystals up to 1 mm. in diameter or as smaller grains between the feldspar of the base; microphenocrysts of sanidine also occur. The ground-mass is composed of microlites of sanidine either quadratic in section or in lath-shaped forms, and there is an admixture of forms with higher index of refraction than that of balsam and with the extinction of oligoclase-andesine, and frequently with denticulate margins. In among them lie stumpy forms of greenish augite and grains of magnetite.

The rocks are related to the ciminite of Washington, but they have too much soda in relation to the potash, too much olivine, and the feldspar is somewhat too acid as well; it will therefore be best to call them merely trachy-andesites. They furnish another instance of the association of hornblende with rocks of this class.

A good example (13 ft.) can be seen on the rock cutting east of Heathcote Valley, another (10 ft.) on the saddle east of the Sugarloaf, the latter showing numerous inclusions of large hornblende with and without matrix attached, as well as a foreign block of granitoid rock 12 inches in diameter. This inclusion is formed chiefly of brown hornblende but contains some diallage as well, a little

biotite, and frequent crystals of apatite and ilmenite, and a subordinate amount of granular feldspar, the granular form being apparently the result of pressure; some of this is andesine, and none was observed with a lower index than that of balsam. This rock is in all probability a diorite or diorite gneiss and may be the deep-seated equivalent of the trachy-andesitic material of the dykes just referred to.

Basic Andesites and Basalts.

Typical andesites are apparently not represented but basic andesites verging on basalts occur freely. They are found first of all as narrow dykes, dark in colour, and frequently as one of the members of a multiple dyke. A case illustrating this is furnished by the assemblage associated with the large trachyte dyke on the Dyer's Pass ridge about half a mile west of the pass. In the hand-specimen this is dark coloured with a fine-grained base in which crystals over 1 cm. in length show up occasionally; the rock is deeply weathered, a feature which applies in other cases. Under the microscope the phenocrysts prove to be labradorite with very occasional augite; the groundmass is composed of feldspar laths, the great majority of which have the low extinction angle corresponding with oligoclase and often have denticulate margins, but there are microlites as well without such borders and with the extinction angle of andesine. If only one plagioclase can be present in such a groundmass they must all be andesine. There are as well grains of magnetite and patches of material with no effect on polarised light, in all probability a glass. Numerous cavities also occur lined with fibrous chalcedony marginal to a brownish aggregate occupying the interior with an index lower than that of balsam, and having some effect on polarised light at minute points, which are occasionally arranged in definite parallel lines in one section of the amygdule and with a similar arrangement but oriented differently in another section. Analysis No. 4 is of this rock. It shows a high percentage of water, and when this is allowed for the composition becomes that of a basic andesite; the norm, too, shows a very high percentage of quartz, no doubt accounted for by the presence of chalcedony.

Similar rocks marginal to trachytes occur on the crest of the ridge at the head of Heathcote Valley, and with some glass in the base as well as numerous vesicles full of yellowish green alteration products. The microlites of the base appear in two forms, one lath-shaped and the other more quadrate, both with index higher than that of balsam. These occurrences appear to be restricted to only short lengths of trachyte dykes, and they appear to have no close relations in composition to them, that is, they are in no sense composite dykes arising from differentiation of a common magma.

Andesite forms the complex dyke east of the Heathcote Valley saddle and occurs much decomposed on the side of the road crossing the ridge leading up to Mt. Ada and near Rhodes's Bush on the south side of Cass Peak. An undecomposed rock also occurs on the southern side of the Sugarloaf as a moderate-sized dyke (6 ft.) cutting the road twice. This contains a few phenocrysts of plagioclase

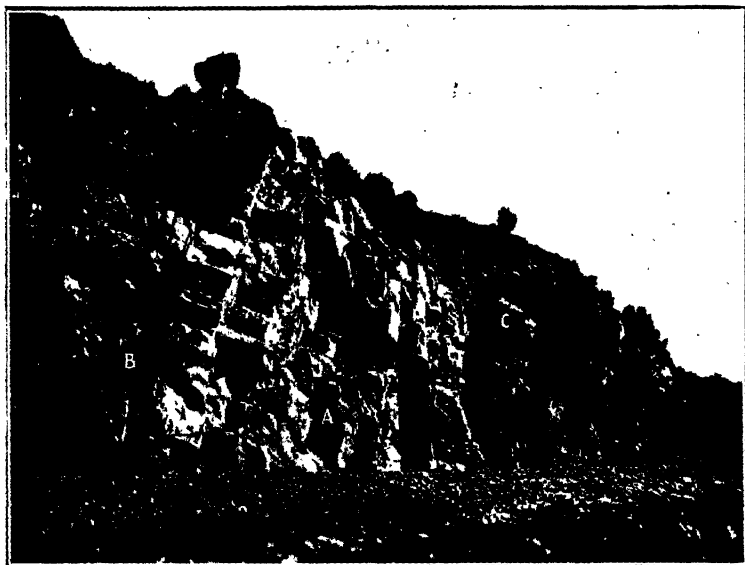


FIG. 1.—Multiple Dyke, Heathcote Valley; trachy-andesite (A) in the middle, with margins of basic rock, 18 in. on left (B) and 5–7 feet on right (C) the basic rock being probably intruded along the walls of the trachytoid dyke.

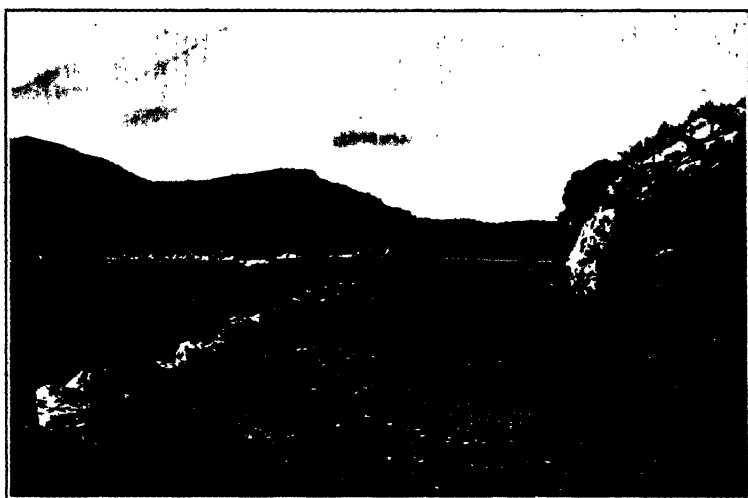
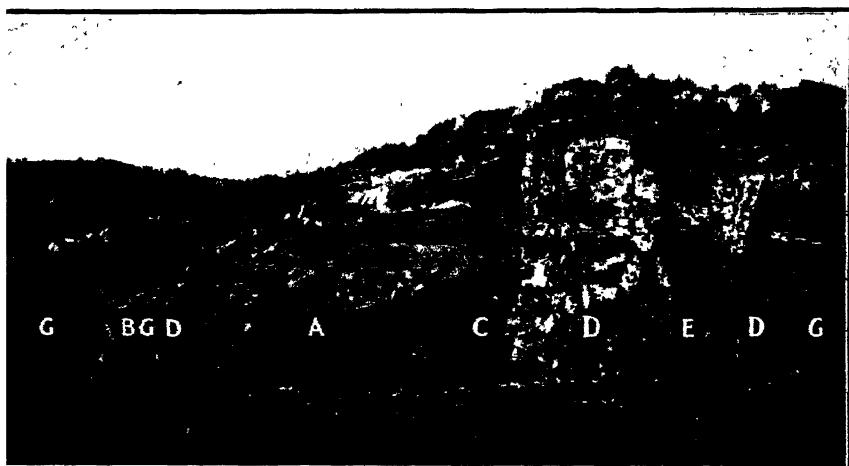


FIG. 2.—Summit Road round head of Heathcote Valley, showing its general character. Trachyte Dyke on the right and outward dipping flows on left.

To face page 96.



1. 3.—Multiple Dyke on ridge west of Dyer's Pass; trachyte (A) in middle; dark-coloured trachy-andesite (B) on left; basic andesite (C) on middle right following up junction of the cross with the platy jointing of the trachyte. The marginal trachytes (D) on both sides show platy jointing, and that on the right contains basic andesite (E), which no doubt owes its position as well as the increased thickness of the platy trachyte (D) on that margin of the main dyke to faulting. On the extreme left (F) is a basalt which shows fluting of the internal part on the external platy facies, while (G) is country rock.

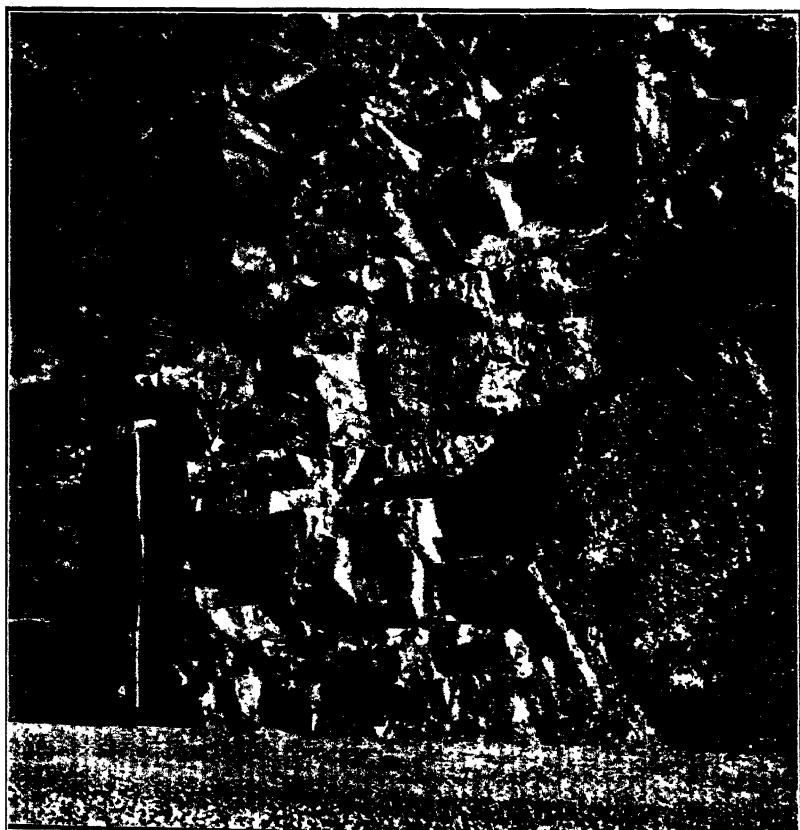




FIG. 5.—Trachyte, Heathcote, showing phenocryst of sanidine in base composed of feldspar laths, many of which show denticulate borders, the texture being trachytic with an approach to bostonitic.

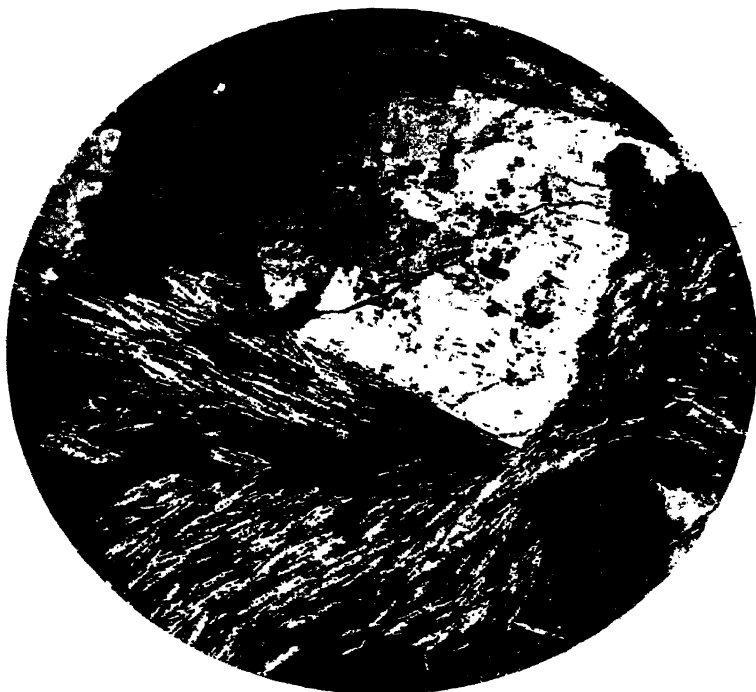


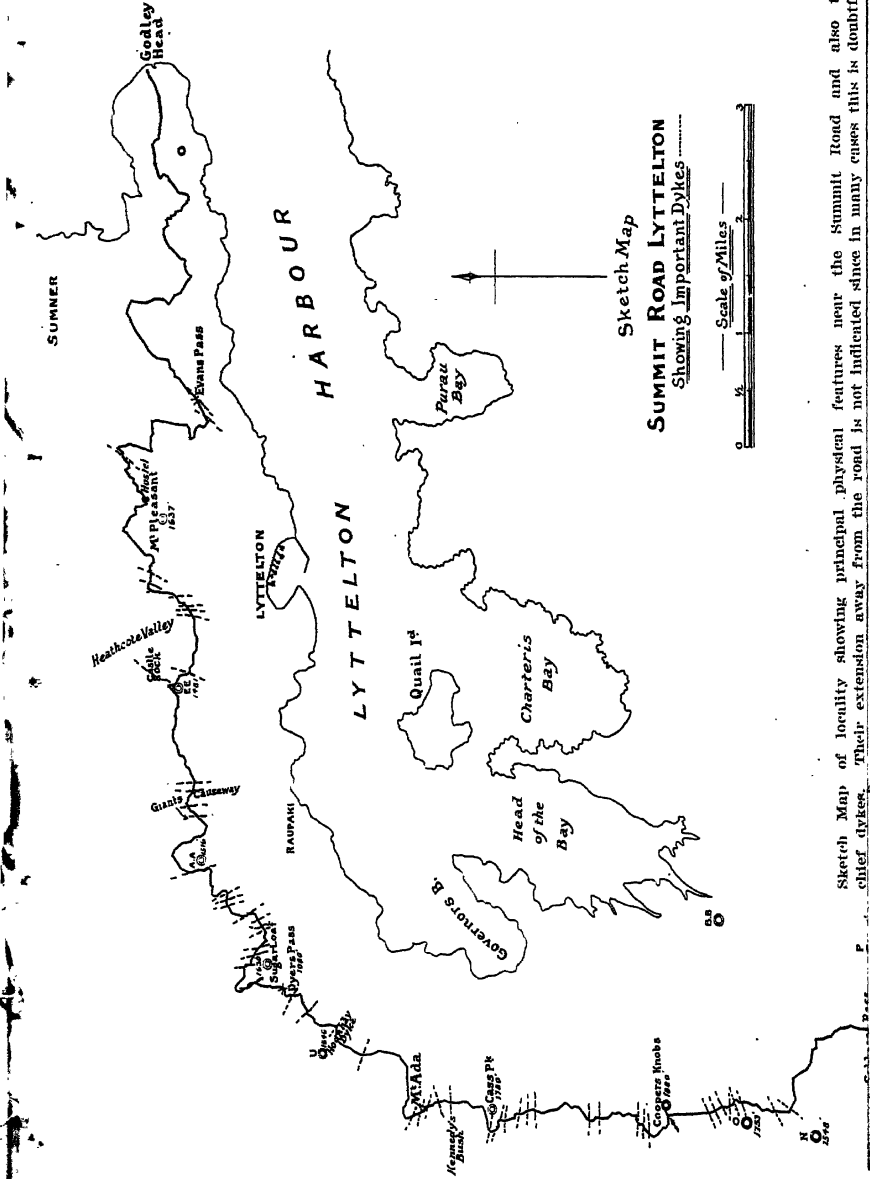
FIG. 6.—Trachyte, Castle Rock, showing feldspar phenocrysts and base of sanidine laths in sheaf-like aggregation.



FIG. 7.—Basic Trachyte, Cass Peak, showing ground-mass of sanidine and albite-oligoclase laths, many being denticulate; the texture is bostonitic.



FIG. 8.—Soda Trachy-andesite, Dyer's Pass ridge, showing base of denticulate oligoclase laths with bostonitic texture. In the dark spaces among the laths are grains of aegirine-augite.



Sketch Map of locality showing principal physical features near the Summit Road and also the chief dykes. Their extension away from the road is not indicated since in many cases this is doubtful.

in a hyalopilitic base with lath-shaped microlites of andesine and grains of augite; and andesites of this grade occur on the cutting leading down from Coopers Knobs to Gebbies Pass. One of these is composed of phenocrysts of labradorite in a base of oligoclase microlites, augite grains and broken-comb forms of ilmenite and patches of brownish glass as well as amygdules of fibrous chalcedony. Other cases of this type show oligoclase microlites with denticulate margin in the base, and in one case the phenocrysts are of labradorite and augite in a base of andesine microlites often arranged with radial grouping and at times showing flow structure, and in between the laths are grains of augite and patches of alteration products green and brown in colour, the amount of F.M. mineral present being unimportant.

A special case of basic andesite occurs as a dyke on the north-east face of Witch Hill just east of the Giants Causeway. The rock is green-grey in colour and under the microscope shows phenocrysts of feldspar up to 1 cm. in diameter, slightly purplish augite, occasional olivine in grains up to 0.1 cm. in diameter, and grains of brownish-black magnetite. The base consists of laths of oligoclase-andesine usually showing flow arrangement, grains and short crystals of greenish to purplish augite, and grains of magnetite. There appears to be a very occasional feldspar which has an index of refraction slightly lower than that of balsam, but by far the great majority of the microlites have a higher index. Amygdules of chalcedony and of tridymite also occur as well as small patches of a greenish anisotropic mineral.

These rocks grade into undoubted basalts, and probably some of them might be classed as such, but it is difficult without analyses to say definitely at times what group they should be assigned to. One of these border-line cases is the basalt with groovings referred to elsewhere in this paper. This is an even-grained rock, without phenocrysts, and composed of laths of oligoclase, grains and short crystals of augite, and grains of magnetite. Sections taken with orientation parallel to the walls of the dyke show no difference in composition or texture from sections taken at right angles. Segregations of coarser texture, most composed of feldspar, also occur.

Undoubted basalts form the 12 ft. dyke on the east side of Heathcote Valley saddle, the core of the multiple dyke near mile post 4, and a dyke cutting the road on the south side of Mt. Ada. The last of these is dark in colour with feldspar and olivine showing occasionally in the hand-specimen. The feldspar proves to be labradorite, but it often has a more acid border. The F.M. minerals are faint violet augite and olivine in grains and aggregations up to 2 mm. in diameter, the latter sometimes fresh and again partly replaced by iron oxides. The holocrystalline base is composed of feldspar laths, augite grains, small olivines and grains of magnetite. The feldspar which makes up the bulk of this rock is of two types, the first, and more common, has approximately straight extinction and has denticulate border, while the other has an extinction angle corresponding to basic andesine, both with index of refraction higher

than that of balsam. If only one feldspar can be present it must be andesine. but if two can co-exist, then there appears to be oligoclase in addition, the extremely large proportion which shows the extinction angle of oligoclase being in support of the contention that both are present. No appreciable difference in texture or composition of the inside from the outside of the dyke was disclosed in slides selected from various parts, although the hand-specimens did suggest a difference.

Analysis No. 4 is of this rock. The most striking feature is the amount of normative albite, which seems to bear out the hypothesis that oligoclase is present in the base.

Some of the rocks which look like andesites in the hand-specimen prove to be undoubted basalts when examined microscopically. A good example of this is the dyke (6 ft.) which crosses the road a few yards south of the Hoonhay dyke and which presents a facies strongly reminiscent of the olivine andesites or feldspar basalts so characteristic of the effusive rocks of the area. In this there are numerous phenocrysts of labradorite 1 cm. in length; olivines up to 2 mm. in diameter with the usual alteration products; somewhat occasional augite; in a base composed of microlites of andesine-labradorite frequently with denticulate margin, grains of augite, small brown olivines, and grains of magnetite. Its composition is given in analysis No. 5, which shows that it is definitely a basalt.

The most basic dyke judged microscopically is the fourth down the cutting from Coopers Knobs and 12 ft. in thickness. The phenocrysts take up fully 50 per cent. of the slide and consist of labradorite, augite, and olivine in sub-equal proportions. The augite is light brown in colour, the olivine sometimes fresh and sometimes seamed and bordered with iron oxide. The base is holocrystalline and composed of short laths of labradorite, grains of augite, olivine, and magnetite; needles of apatite and alteration products of iron-oxide occur as well. Analysis No. 7 gives the composition of this rock.

I have left to the last all reference to the hornblende basalts which present certain interesting features. This type has been referred to by Bartrum (1917, p. 416) and by the present author (1923, p. 144), the rock referred to being a dyke in Sumner Valley which does not appear to cut the Summit Road. An excellent example can be seen in a dyke (6 ft. 6 in.) on the rock cutting east of Heathcote Valley (fig. 4). In the hand-specimen this rock is grey with a slight tint of green; it is very vesicular and shows crystals of hornblende up to 5 mm. in length, also very occasional feldspars in a base which shows well-marked flow structure. Under the microscope the phenocrysts appear as brown hornblende, sometimes resorbed; light purplish augite in sporadic crystals and in concentrations; olivine, fresh and stained with iron-oxide; very occasional microphenocrysts of plagioclase with higher index of refraction than balsam; grains of faintly brownish magnetite (?titaniferous); all in a base of lath-shaped microlites and more quadratic forms of andesine, twinned and untwinned, with definite flow arrangement, forms of greenish grey augite and grains of magnetite. This basalt is entirely different in facies from the other basalts cut by the road.

It is not intended in the present article to refer in particular to the rocks into which these dykes have been intruded. It will be sufficient to say that they consist of flows of feldspar basalt or basic andesite and ordinary basalts, coarse agglomerates of the same materials, and finer ash beds, some of the last simulating at times the andesitic flow macroscopically. Their age is late Tertiary, perhaps even early Pleistocene.

I have also in addition to acknowledgements mentioned earlier to record my indebtedness to Miss Thelma Kent, A.R.P.S., for the micro-photographs, and to Mr G. Stokell for material assistance also in connection therewith.

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The Supposed Flightless Duck from Campbell Island.

By E. F. STEAD.

[Read before the Canterbury Branch, Royal Society of N.Z., September 15, 1937; received by the Editor, December 15, 1937; issued separately, June, 1938.]

In occasional papers of the Royal Ontario Museum of Zoology, No. 1, J. H. Fleming describes "A new genus and species of Flightless Duck from Campbell Id." He says: "The genus may be known as *Xenonetta*, gen. nov. Bill narrow, not broad as in *Nesonetta*; culmen line and sides of the maxilla nearly straight; lamellae and maxillary flap poorly developed; nail shorter and rounder than in *Nesonetta*; nasal openings small and oval. Mandible narrow, the gnathidia compressed at the base. Wings short, the shafts weak; tail wedge-shaped, the shafts stiff. Tarsi reticulate." In regard to the last specification he adds a foot-note: "I hesitate to use this as a generic character, but the scales are clearly reticulate in this specimen."

If this description be examined, and specimens of *Nesonetta* from Auckland Islands compared with it, I do not think there is any justification for making a new genus or even species of this bird. Firstly the bill, "narrow, not broad": In the dozen or so skins of *Nesonetta* which I have examined in Auckland and in Christchurch there are all shapes of bill, from broad to very narrow; in some the bill is very narrow and quite straight and parallel on the sides. There is a considerable variation in the development of the lamellae and the maxillary flap, a specimen in the Christchurch Museum showing no more than Fleming shows in his illustrations of his bird. The nail in some specimens is practically the same as shown in his drawings for *Xenonetta*, while the under view of the supposed new genus' bill can be perfectly matched by the bill of a specimen from the Auckland Museum. Actually there is a very great variation in the shape and form of the bills of specimens of *Nesonetta*, due, no doubt, in part to the age of the specimens when killed, and the manner in which the bill was subsequently dried. The accompanying plate shows photographs of the bill of a specimen of *Nesonetta* just taken out of spirits. It will be noted that the gnathidia are spreading at the base. This bird was subsequently skinned, and after 48 hours' drying the gnathidia were compressed at the base, proving that this character is of no value diagnostically.

In the reticulate tarsus, Fleming himself places little reliance, so it will suffice to say that I have examined tarsi showing similar reticulations to those of his plate in both *Nesonetta* and *Elasmonetta*.

Fleming's description of the colouring of his bird fits specimen Av. 166.3* from the Auckland Museum, excepting for the feathers of the lower breast and abdomen which in the Auckland Museum bird have wide edgings of pale buff. His coloured figure† of the

* Av. 166.3 is labelled female, and is probably in its juvenal plumage.

† A hand-coloured figure of the type specimen sent by Mr. Fleming to Mr. R. A. Falla, Director of the Canterbury Museum.



FIG. 1.—Profile of the bill of *Nesonetta aucklandica* before drying (spirit specimen).

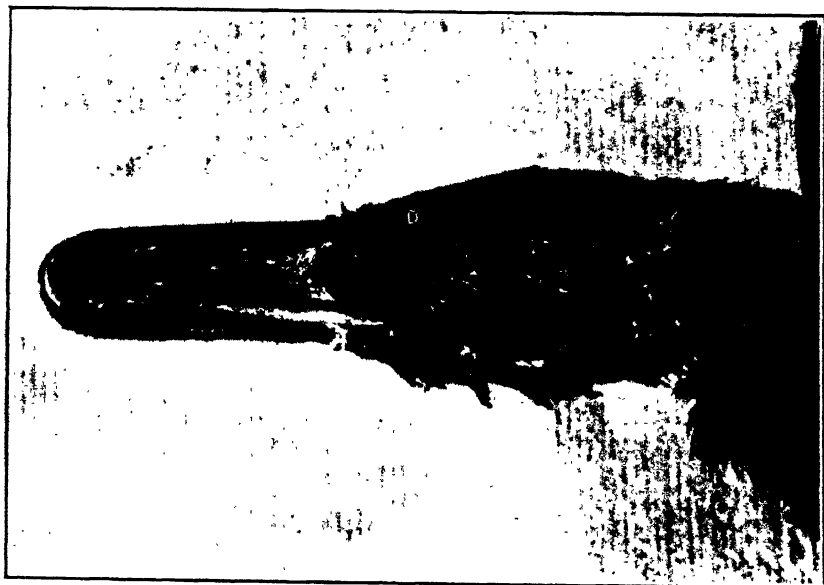


FIG. 2.—Mandibles of above, before drying (spirit specimen).

To face page 100.

head and neck of *Xenonetta* show these parts to be identical with those of Av. 166.3, whose bill, which measures 34 mm., is narrow, not broad, and has the curious lines on the underside of the nail referred to by Fleming as a character of *Xenonetta*.

It is not only because the differences described by Fleming appear to me to be insufficient to warrant him in describing his bird as new, but also because I regard as insufficient the evidence that the specimen came from Campbell Island. It is true that it is labelled as from there, but mistakes in labelling birds are by no means uncommon, and a mistake such as this one could easily occur through a slip of the tongue by Captain Fairchild or an error on the part of Captain T. E. Donne. Captain Fairchild would no doubt have been mentioning several of the sub-antarctic islands and may unintentionally have given Captain Donne the impression that the bird came from Campbell Island, or the error may have been Captain Donne's. It must be remembered that, even to-day, very few New Zealanders who have not actually been to the sub-antarctic know anything about the islands there.

If a flightless duck had been obtained from Campbell Island it seems incredible that no one should have heard of it for fifty years. Reischek is reported by Fleming to have been told that flightless duck were on this island, but he did not see any. Surely this should be regarded as evidence *against* the existence of the duck there, rather than *for* it. Had Reischek not been told this, he might not have looked for the bird, but having been told it, he would certainly have made every effort to find it. I have asked two men in Bluff who were on Campbell Island for some years as shepherds if they had ever seen or heard of a flightless duck there, and they said they had not—that there were grey duck (*Anas superciliosa*) there, but no flightless duck. Captain Fairchild for many years after he is supposed to have taken this duck was in constant touch with Sir W. L. Buller. Throughout the latter's *Supplement to the Birds of New Zealand* he constantly acknowledges information and gifts of southern birds which he had received from Captain Fairchild. How can it be imagined that Fairchild, if he had taken a flightless duck on Campbell Island, should never have mentioned the extremely interesting fact to Buller?

Perhaps, however, the most conclusive evidence on this point is that of Mr. A. W. Bethune, late engineer of the Government boats, who visited the Campbell Islands on many occasions from the eighties onward. Mr. Bethune was a keen collector on these southern cruises and brought back many specimens of birds and eggs to Buller and others. In a letter to the writer he states that he never heard of a flightless duck being found in this locality. Mr. Bethune joined the Government steamer "Stella" on 4th June, 1885,* and would therefore have been on the "Stella" at the time when this flightless duck is supposed to have been collected on Campbell Island; yet he did not hear of it. In the face of this evidence, I think we may reasonably dismiss the claim that Mr. Fleming's specimen came from Campbell Island as unsubstantiated.

* Letter to the writer from the Secretary of the Marine Department, Wellington.

"Eclipse Plumage," possibly a Universal Factor in the Sequence of Moults in Ducks.

By EDGAR F. STEAD.

[Read before the Canterbury Branch, Royal Society of N.Z., September 1, 1937; received by the Editor, December 14, 1937; issued separately, June, 1938.]

THE eclipse plumage in ducks is regarded by some authorities as a plumage of inconspicuous hues designed to aid the drakes in concealing themselves during that period when they have moulted all their wing feathers and are unable to fly. By others, however, it is regarded as a winter or non-breeding plumage as distinct from a summer or nuptial plumage.

If this latter view is correct, and I believe that it is, then one would expect that other species as well as those whose males have a brilliant nesting dress would undergo a double moult. The Grey Duck of New Zealand (*Anas superciliosa*) and the Black Duck (North-eastern America, *Anas rubripes*) may be taken as typical of those ducks in which the male and female have the same colouring throughout the year. In his "Life Histories of North American Waterfowl" (*Bulletin 126, United States National Museum*) A. C. Bent, dealing with the Black Duck, says: "I have often been asked if the Black Duck has an eclipse plumage with the double moult common to all the surface-feeding ducks. The eclipse plumage, if it had one, would not be conspicuous and the double moult could be detected only by dissection or close inspection. It begins to moult very early in the summer and is in more or less continual moult for three months or more, but, as there is no necessity of an eclipse plumage for concealment, I doubt if there is an actual double moult. Lord William Percy, the British expert on ducks, tells me that none of the ducks in which the sexes are alike have an eclipse plumage; probably he is correct in this statement. The Black Duck then has probably only one moult, the post nuptial, which is prolonged and complete."

For many years I have thought that the Grey Duck had an eclipse plumage because I found freshly moulted feathers in the ducks' haunts throughout the winter. Further, if the double moult in the male was not especially for purposes of concealment, but was to give him "breeding" and "non-breeding" dresses, then it seemed to me probable that the females would have a double moult also. To settle the matter one could choose no duck better than our Grey Duck, but the birds selected for experiment must be pure—there must be no trace of Mallard cross in them. In January last I found the birds I wanted in Auckland—they were pure Grey Duck kept for the Acclimatisation Society in a large covered enclosure by Mr. F. G. Newell. On January 18th some of these birds were heavily in the moult, while some had just completed it, being in perfect plumage with not a frayed feather on them. Selecting two drakes and a duck of these latter, I trimmed with a pair of scissors patches of feathers on the breast, belly, hind neck and top of the head; I further clipped the ends off all the larger scapulars, and squared

the ends of the primaries of one wing. With Mr. Newell's assistance I ringed the legs of these birds for identification and went back to look at them on August 11th. In both of the drakes all the feathers I had marked had been replaced by new ones save the primaries, while the duck still retained one clipped scapular as well as the clipped primaries. Mr. Newell told me that new feathers began to replace clipped ones within six weeks, the marks on the neck and breast being first effaced. As these birds had not completed their post-nuptial moult by more than a fortnight when I clipped them, the post-nuptial dress is worn for only about two months. The replacement feathers in both moults are the same as the moulted ones, and there would be no difference in the plumage of a Grey Duck when it had completed its post-nuptial moult in January or its pre-nuptial moult in August. This applies to both sexes. Here, then, is definite proof that the Grey Duck has an "eclipse" plumage, although in no need of one for purposes of concealment, and I have no doubt that the long moulting period of the American Black Duck described by Bent is in reality two complete changes of plumage.

The discovery of the double moult in the female Grey Duck is very interesting, for it indicates that a double moult is probable in both sexes of those species in which the drake has an eclipse plumage, but as the change of plumage is not accompanied by any change of colouring, it has not been observed. It could only be detected with certainty by marking birds and keeping them under observation. It indicates also the possibility that many other ducks which are to-day regarded as having only one moult annually may actually have a double moult, without any change of colouring.

Of the Ruddy Duck (*Erismatura jamaicensis*) of North America it is said in Bent's book: "The Ruddy Duck is one of the very few species which have a strictly nuptial plumage and two extensive moults." I believe that when more species are carefully examined it will be found that this procedure is the rule rather than the exception, though the two moults may not be spaced as far apart as in the Ruddy Duck.

The case of the Paradise Duck (*Casarca variegata*) is especially interesting. It is a very general rule in the bird world that where the adult sexes of a species differ in colouration, the young in their juvenal plumage resemble the hen, and to this rule the Paradise Duck is one of the outstanding exceptions. In their juvenal plumage all the young resemble the adult drake, having black heads and dark vermiculated feathers on the back and breast. In their first moult, which occurs when they are about four months old, the females get a white head and ruddy feathers on the back and breast, while the drakes retain their juvenal colouring. Now it is the drakes of most species which exhibit the greatest change from the juvenal to the adult plumages, and it is the drakes which, in the eclipse plumage, revert towards their juvenal colouring. In the Paradise Duck the position of the sexes being reversed, it is interesting to find that the duck has an "eclipse" plumage while the drake has not. She retains the white head, but the ruddy feathers of back and breast give way to dark feathers as in the drake. Her moult into "eclipse"

is completed in a short time early in January, and by early March she begins to grow her red "summer" feathers, but she does not complete this moult until July or August, ready for the nesting season which commences in September.

I expect to find that the Paradise Drake also has two moults, although he does not change his colouring.

The sequence of the moults in those ducks in which the moult is unaccompanied by a change of colouring would be very difficult to follow in wild birds; it is therefore fortunate that a great many species of ducks are kept pinioned on ponds for ornamental purposes. I suggest that a close study of these will lead to the discovery that many more species of duck, both male and female, indulge in a double moult than is at present suspected.

Further Observations on Moult in the Duck Family.

By E. F. STEAD.

[Read before the Canterbury Branch, May 3, 1938; received by the Editor, May 12, 1938; issued separately, June, 1938.]

IN the interval since I wrote my last paper on this subject I have found that the principle of a double moult in the Anatidae is of much wider application than I had then thought. Since the opening of the shooting season on May 2, 1938, I have examined about thirty specimens, male and female, of Paradise Duck (*Casarca variegata*), and every one of them has had new contour feathers growing. In the case of the young birds, there may be very few new feathers, but birds a year or more old show a sprinkling of new feathers throughout, though in no case sufficient to give any external indication of a moult. From this two important conclusions follow:—(1) The young birds shed their juvenal plumage, retaining their flight and tail feathers, in February, March or April, according to the original date of hatching. These birds do not moult again until the season of the post-nuptial moult, when they are about one year old. (2) In the case of the Paradise Duck, the drakes as well as the ducks have a double moult, as suggested in my previous paper. Young Grey Duck (*A. superciliosa*) also moult their juvenal contour feathers in the autumn.

The sequence of moults shown by a tame Canada Goose (*Branta canadensis*) kept in my own garden may be recorded as follows:—Late in December its flight feathers began to fall, and at the end of ten days all were shed. At the same time a few of the body feathers were being moulted, but it was not until the flight feathers were nearly grown again that the body moult set in heavily. By the end of February the whole moult was complete, and I then clipped feathers on the head, neck and breast, and trimmed the light edges off the scapulars on one side of the body. Within a month the head and neck feathers were being quickly replaced with new ones, and new scapulars began to appear. This second moult is now (May 13) almost complete, there being only two or three clipped scapulars left. The cuts in the head and neck feathers are completely effaced, though a few new feathers are still coming in these parts. The goose in question is a male; but I do not doubt that the female also has a double moult.

Late in April, I caught and examined some adult White Swans (*C. olor*). I found new feathers, including scapulars, growing, and moulted feathers on the water, most of which were not at all frayed at the edges. I found also a few moulted feathers much frayed at the edges, indicating that they had been worn by the bird for a long time. The unfrayed moulted feathers would be post-nuptial moult feathers, and the frayed ones those assumed at

the pre-nuptial moult. The White Swan therefore also has a double annual moult. A tame Black Swan (*Chenopsis atrata*) which I watched closely shed odd feathers throughout the autumn, indicating that it too has a double moult.

From the foregoing I think it most probable that all the members (including both sexes) of the order Anatiformes have a double moult annually, some of the feathers assumed during the post-nuptial moult being carried for a very short time (six weeks or less). It would seem also that in some cases, if not in all, the flight feathers are shed before the contour feathers, so that the theory that brilliantly coloured drakes had an inconspicuous plumage to afford them protection during their flightless period seems not to accord with the observed facts. I have seen and heard of drake mallards which were flightless yet still retained their iridescent head and nuptial body feathers. The term *eclipse plumage* becomes in some cases therefore a misnomer, and it would probably be better if the two plumages were referred to as *post-nuptial* and *pre-nuptial* respectively.

Petrofabric Investigations of Otago Schists.**No. 2—Three Quartz-Albite-Sericite-Schists from Waipori.**

By F. J. TURNER, University of Otago.

[*Read before the Otago Branch, November 9, 1937; received by the Editor, November 10, 1937; issued separately, June, 1938.*]

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Mica Fabric and Fold Structures.
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INTRODUCTION.

THIS is the second paper of a series in which structural features of Otago schists are being recorded. The rocks investigated were collected about four miles south of the old township of Waipori, eastern Otago (No. 4487, old copper mine, Reedy Cr., $1\frac{1}{2}$ mls. W.S.W. of Trig. C.C., Tuapeka East Survey District*; Nos. 4489, 4492, dam, Reedy Cr., $\frac{1}{2}$ ml. N. of old copper mine). The laboratory work was carried out in the same manner as was described in the first paper (Turner, 1938).

MEGASCOPIIC FEATURES OF THE FABRIC.

In the rocks of both localities schistosity is well defined and dips west-south-west at angles of 10° to 15° . This is typical of the schists of the Waipori district, for the schistosity here is usually subhorizontal though locally dipping as steeply as 45° . Lineation with a trend of 170° to 175° is especially noticeable in the more micaceous laminae. In No. 4487 there is also a coarser and less distinct lineation at 160° .

Quartzose veinlets ranging from 2 mm. to 20 mm. in thickness and usually spaced at intervals of 10 mm. to 20 mm. are ubiquitous, and invariably lie parallel to the schistosity. Traces of the principal lineation (170° to 175°) were occasionally noticed on the surface of coarser veins in specimen No. 4487. True foliation is obscure in Nos. 4489 and 4492 and altogether absent in No. 4487.

As is commonly the case in eastern Otago, the joints, all more or less vertical, fall into several distinct systems. The strongest and most regular have a strike of 75° or 80° , but there is also a prominent series the trend of which varies between 40° and 50° . Less numerous but very distinct and continuous joints were observed from 145° to 155° .

* See north-eastern portion of map accompanying Marshall, 1918.

PETROGRAPHY.

No. 4487 is a rather fine-grained rock consisting of albite, epidote, chlorite, dusty graphite, less plentiful quartz and sericitic mica, and accessory sphene and apatite. As is usual in schists from the Chlorite Zone of Otago, the albite contains no appreciable anorthite. The epidote mineral occurs in colourless idioblastic or subidioblastic prisms; much of it is clinozoisite but there are also many crystals with medium iron-content as indicated by their higher birefringence. The chlorite is a pale faintly pleochroic type; the majority of the flakes are negatively elongated and give yellowish-brown anomalous interference tints, but some are positively elongated and appear deep violet-blue between crossed nicols. The average grain-size is 0.1 mm. to 0.2 mm.

Lineation parallel to b as seen in ab sections is the result of orientation of mica and much of the chlorite with long axes of the flakes in parallel position. Well defined foliation, the mean direction of which is perpendicular to the schistosity, is obvious in sections cut parallel to ac and ab . Individual foliae, usually 0.2 mm. to 2 mm. in width, are marked by concentration of particular minerals, especially albite + chlorite and epidote + graphite; sericite-rich foliae are less common. The trend of the foliation in the ab section crosses the main lineation at an acute angle and is parallel to the indistinct macroscopic lineation b' . In the ac section the foliae have been contorted by transverse shearing (Pl. 21, Figs. 11 and 12) and are cut by rather poorly-defined widely-spaced planes of shear, along which parallel flakes of mica have crystallised, thus giving rise to the present schistosity.

The quartzose veins are seen in section to consist principally of quartz, with albite, colourless iron-poor epidote and chlorite as minor constituents. The quartz is in interlocking equidimensional grains ranging from 0.1 mm. to 1 mm. in diameter and usually showing faint traces of undulose extinction. The grains of albite are smaller, never twinned, and usually aggregated into highly irregular streaks trending approximately parallel to b . As seen in the ac section the epidote prisms appear to lie perpendicularly to the vein-wall, but in bc sections they lie on transverse subparallel curved arcs, though the individual crystals are not distorted. Chlorite occurs mainly as flakes of late origin margining the veins and parallel to the vein-walls. Micro-cracks parallel to ac were occasionally observed in bc sections. In the ab section of one of the thicker veins* there are a few prominent cracks parallel to b and numerous well-defined cracks at 135° to b . The latter lie within 10° of macroscopic joints noted in the field at 145° to 155° .

* No. 5 on hand-specimen 4487, Geology Department, University of Otago.

Nos. 4489 and 4492 are rocks that have suffered more complete shearing and recrystallisation during that stage of metamorphism in which the present schistosity developed. They are therefore of somewhat coarser grain than No. 4487, the schistosity is better defined, and the original foliation has been sufficiently obliterated to be invisible in hand-specimens. In sections cut parallel to *ac*, however, micaceous and feldspathic foliae that have developed parallel to the schistosity *ab* alternate with lenses in which the transverse arrangement of mica flakes parallel to the *c* axis of the rock is still perfectly preserved. The micas in such lenses show strong effects of deformation accompanying crystallisation (Pl. 21, Fig. 13). The rocks are much richer in mica than No. 4487, and consist of albite, sericite, chlorite, epidote, quartz, graphite, and accessory sphene and brown tourmaline. The grains of quartz and albite range from 0.2 mm. to 0.7 mm. in diameter, the latter mineral occasionally forming porphyroblasts with enclosed prismatic clinozoisite. The chlorite is positively elongated and gives anomalous violet-blue interference tints. Much of it seems to have recrystallised at a late stage as augen composed of rather coarse undeformed flakes oriented transversely with respect to the schistosity as seen in *bc* sections.

The quartzose veins cutting these rocks consist mainly of quartz and albite (15% to 20%), with coarse chlorite of late origin near the margins. Epidote is an accessory constituent only. In several veins the grains of albite are elongated perpendicularly to the vein-wall. Attention may here be drawn to the invariable absence of mica from quartzose veins of the Waipori schists. On the other hand, mica is plentiful in what are believed to be much more ancient quartz veins in the schists from Patearoa described in the first paper of this series.

MICA FABRIC AND FOLD STRUCTURES.

In curves (Figs. 2 and 3) representing the mica fabric, the angular distance is plotted between the trace of the (001) cleavage and *b* (for *ab* sections) or *a* (for *ac* sections) respectively. The *ab* curves for all three rocks (Fig. 2) show strong maxima at *b*, indicating that the mica flakes lie with their long axes parallel to *b*. A submaximum at 15° from *b* in the curve for No. 4492 corresponds to the second lineation *b'*, but in the other two rocks the *ab* mica curves give no hint of relation to the original foliation (*b'c*) even though the latter is clearly visible in one of the microsections (No. 4487). An additional maximum at 155° from *b* in the curve for No. 4487 seems to be related neither to the quartz fabric nor to the megascopic fabric of the rock as a whole.

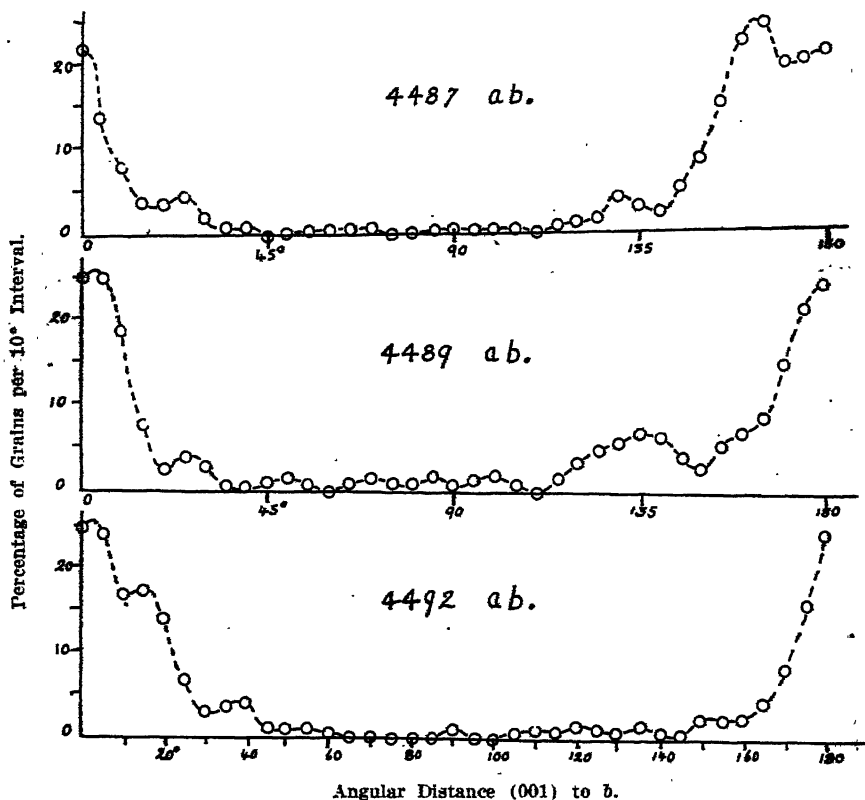


FIG. 2.—Orientation curves for mica in sections cut parallel to *ab*. The percentages refer to the number of crystals in which the trace of the (001) cleavage lies within 5° on either side of the particular angular distance from *b*.

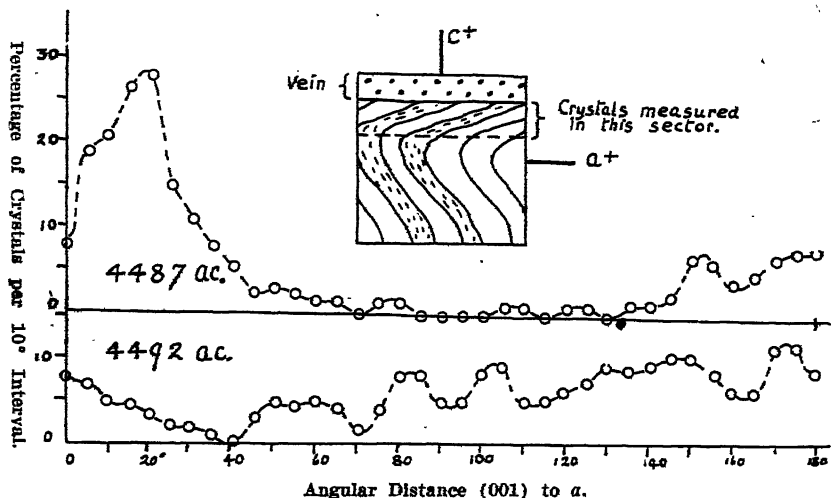


FIG. 3.—Orientation curves for mica in sections cut parallel to *ac*. The relation between the early *S*-planes and the fabric axes in the sector within which crystals were measured in No. 4487 is indicated diagrammatically.

Comparison of *ac* sections for Nos. 4487 and 4492 illustrate the way in which the mica has attained its present orientation. In the former the flakes of mica, many of which show effects of mechanical deformation, for the most part lie parallel to the sinuous boundaries of the contorted foliae in which they occur. The corresponding curve (Fig. 3), drawn from measurements of crystals in a restricted area of the section, shows also a slight tendency for mica to develop parallel to the schistosity. In the curve for No. 4492 (Fig. 3) the orientation of 600 flakes scattered over the whole section is represented. Metamorphism has here reached a more advanced stage, in which the original mica fabric has been partially destroyed and is becoming replaced by a fabric dominated by crystals parallel to *ab*. Here, too, most of the crystals of mica are obviously deformed by movements accompanying crystallisation.

Sharply crystallised post-tectonic micas are also present in all three rocks. The greater number lie parallel to *ab*, often margining the veins of quartz, but in some cases the orientation follows the old foliation.

Three stages in the evolution of the mica fabric may therefore be recognised:—

- (1) Crystallisation of flakes parallel to the early foliation, i.e. to *b'c*.
- (2) Deformation across the *b* tectonic axis giving rise to a subhorizontal schistosity. At the same time mica flakes were brought into alignment parallel to *b*, and in the surfaces of maximum differential movement approximately parallel to the plane of schistosity *ab*.

(3) Post-tectonic crystallisation of a small proportion of crystals parallel to already existing structures.

Sander (1930, pp. 243–262) has discussed the nature, origin and diagnostic criteria of the folded structures so commonly encountered in deformed rocks. He recognises two extremes, viz., shear-folds and flexure-slip-folds, together with intermediate types combining to some extent the characters of both (see also Knopf, 1933, pp. 464–467; Fairbairn, 1937, pp. 96–102). While the former originate by shearing parallel to the axial plane of the resultant folds, the typical flexure-slip-fold is produced by flexing of layers of varying competence, combined with a slipping movement between adjacent layers. The undulating structure of the early S-surfaces in the Waipoua specimen No. 4487, while not constituting a series of pure shear-folds, has nevertheless originated by subhorizontal shearing along rather widely spaced surfaces (*ab*) parallel to the axial planes of the folds (cf. examples from New York State figured by R. Balk, 1936, pp. 712, 715, 717). Such an origin is indicated by the following:—

(1) Orientation of the schistosity parallel to the axial planes of the folds (cf. Fairbairn, 1937, p. 100).

(2) The subhorizontal disposition of the axial planes. This is consistent with "folding" by non-homogeneous horizontal shear or by vertical compression. The latter alternative seems hardly possible.

(3) Absence of the structural criteria of flexure-folding as enumerated by Sander, e.g.: there is no sign of thickening of mechanically weak bands at the crests of folds as a result of migration of material during flexure, nor is there any relation between the size of the folds and the thickness of the individual bands.

(4) Comparison with the more strongly deformed rocks (Nos. 4489, 4492), in which the observed structures are obviously the result of shearing of greater intensity and along much more closely-spaced surfaces than in No. 4487. (Hence the well-defined schistosity and nearly complete obliteration of the early S-planes in the two former rocks.)

. On the other hand the mica-fabric in the contorted bands of No. 4487 is non-homogeneous with reference to ab the plane of shearing. Thus while the mica flakes in the limbs of the folds show a strong tendency towards orientation parallel to the S-surface at the point in question, there is only a slight tendency for a tangential arrangement of flakes at the crests. In a pure shear-fold there should be a homogeneous fabric and the micas as seen in the ac section should lie with their long axes parallel to a , the direction of shearing (Sander, *loc. cit.* pp. 251, 261). Since the mica crystals as seen in ab sections define b the tectonic axis of the deformation under discussion, it can hardly be argued that the present orientation of the micas is a result of post-tectonic crystallisation in the contorted S-surfaces (cf. Fig. 1). The mica-fabric is therefore inconsistent with a hypothesis of pure shear-folding.

Finally it may be noted that the folded structure discussed above is quite unrelated to the secondary flexure-slip-folding (with axial planes parallel to bc) not infrequently seen in schists from various parts of Otago. For example the "crumpled schists" described by J. B. Mackie (1936, pp. 136, 140) from the eastern end of the Dunstan Range exhibit the features of typical flexure-slip-folds as described by Sander.

THE QUARTZ FABRIC.

Throughout the main portion of each specimen albite greatly predominates over quartz, and it was therefore usually impossible to measure sufficient quartz grains to construct orientation curves except in sections cutting the ab quartz veins. The following observations therefore refer for the most part to the quartz fabric as developed in veins of this type.

(a) *Fabric in Specimen No. 4487.* In all 660 grains were measured in ac sections cut from three separate veins (numbered 1, 2 and 4 respectively on the section block). The three orientation curves agree sufficiently well to allow combination into a composite curve (Fig. 4) in which five maxima (D, E, G, H and J) may be recognised. All three of the component curves drawn for the individual veins show maxima corresponding to E, G, H and J, while D is represented on the curves for veins 1 and 2.

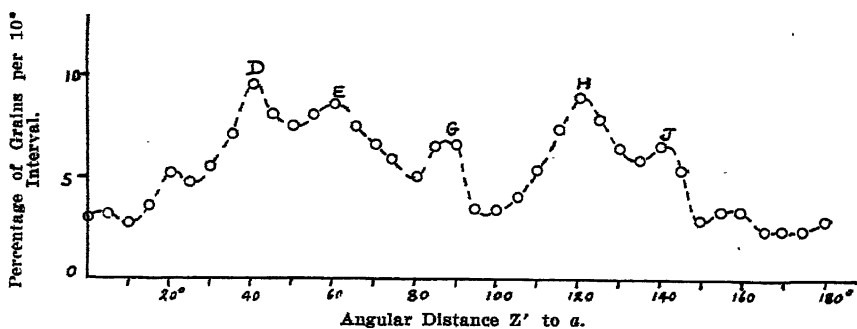


FIG. 4.—Composite orientation curve for quartz in sections cut parallel to *ac*. The percentages refer to the number of quartz crystals having *Z'* lying within 5° on either side of the angular distance from *a*. Specimen No. 4487.

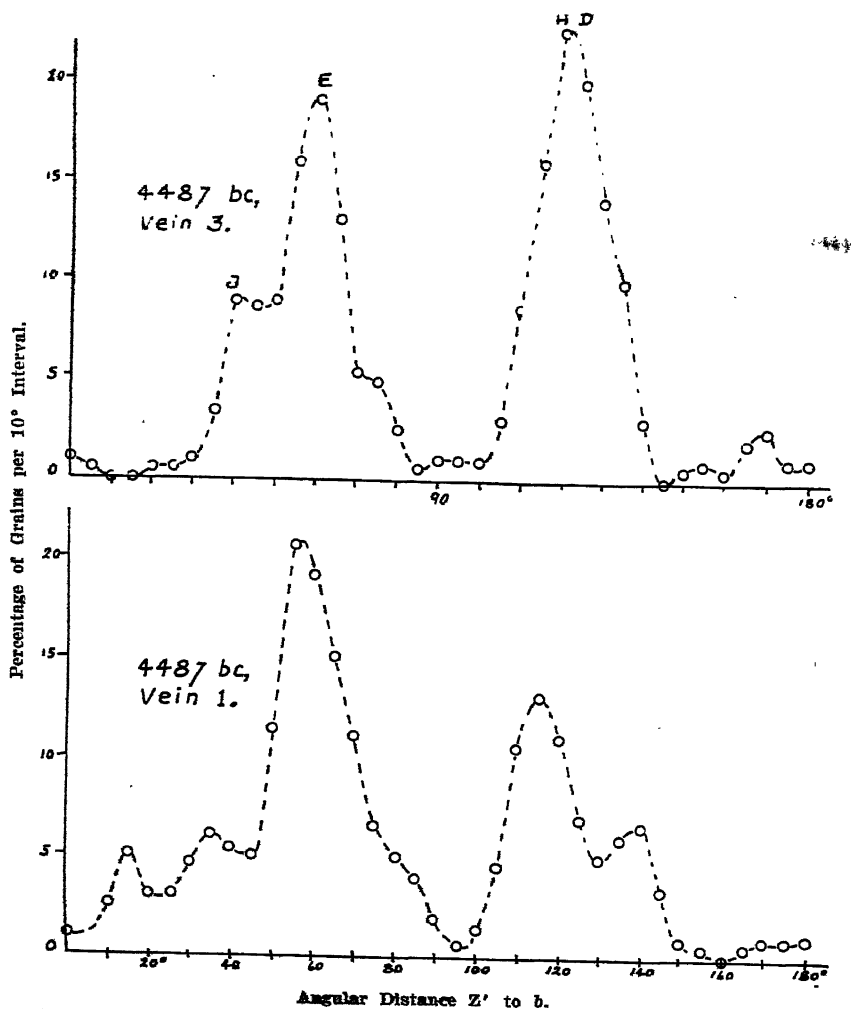


FIG. 5.—Orientation curves for quartz in sections of two quartz veins cut parallel to *bc*. Maxima are lettered to correspond with those in the *ac* and *ab* curves (Figs. 4 and 6).

Curves drawn for sections cutting two veins (1 and 3) parallel to bc are closely similar to each other (Fig. 5). There are strong maxima at 57° and 116° from b in one case compared with 60° and 120° in the other. A submaximum at 40° is also present in both curves, but is much more definite in that for vein 3.

Curves for ab sections of two veins (3 and 5) and a quartz-rich folia in the schist agree in that all possess strong maxima at 125° to 132° from b (Fig. 6). A prominent double maximum at 45° to 60° in the case of vein 3 corresponds to one at 40° to 50° in the curve representing the quartzose folia. A further maximum at 105° (i.e. perpendicular to b') is well developed in curves drawn for vein 5 and the folia, but absent from the third curve.

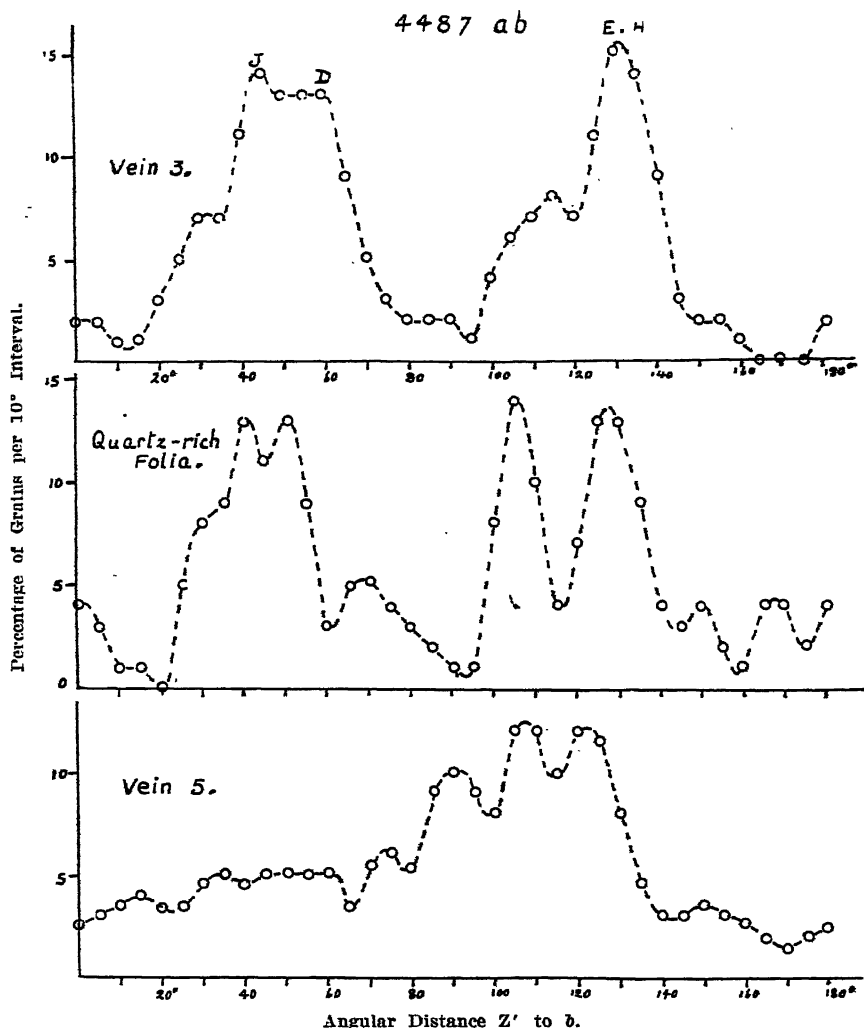


FIG. 6.—Orientation curves for quartz in sections of two quartz veins and a quartz-rich folia cut parallel to ab (all in specimen No. 4487). Maxima in the curve for Vein 3 are lettered to correspond with those in ac and bc curves (Figs. 4 and 5).

4487.

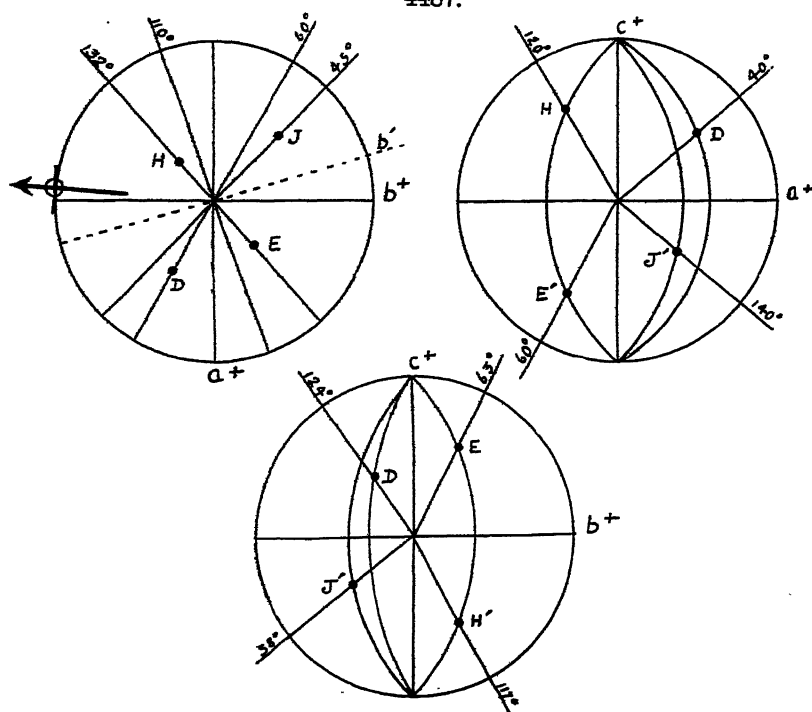


FIG. 7.—Stereographic projections upon ab , ac and bc showing positions of maximum concentration (solid circles) of quartz axes (Z) in Vein 3, specimen No. 4487. The ab and ac projections are plotted directly from corresponding curves (Figs 4 and 6). In the bc projection the maxima have been graphically determined from the other two. Lettering corresponds with that in Figs. 4, 5 and 6.

The fabrics of the quartz veins are thus far from simple and are not all identical. From the close similarity of the curves concerned it may be assumed, however, that the same type of fabric prevails in veins 1 and 3 and in the one quartz-rich folia measured. In correlating the maxima present on ab , bc and ac curves, the most definite results should be obtained by comparing the ab and bc curves for vein 3 and the composite curve for ac sections. Several correlations of these three curves are possible, but that summarised in Table I is quite the most satisfactory and further accords well with the fabric data determined for the other two rocks. The calculated maximum for bc shown in the third column is the value graphically determined by correlating appropriate maxima on the curves for ab and ac sections.* Agreement with the actual maxima for the bc curves (fourth column) is very close. In the absence of a maximum parallel to b in the curves for ab sections, the maximum at G in the ac curve must be due to slight concentration of grains with their optic axes (Z) parallel to the c fabric axis. This is not indicated in the two bc sections measured, but a corresponding feature does show clearly in an orientation curve for quartz in a bc section of specimen No. 4492.

* The graphical method is described in the first paper of this series.

TABLE 1.

Maximum in <i>ac</i> curve.	Correlated Maximum in <i>ab</i> curve for vein 3.	Estimated Maximum in <i>bc</i> curve.	Observed Maxima in <i>bc</i> curves of veins 1 and 3.
D (40° from <i>a</i>)	60° from <i>b</i>	124° from <i>b</i>	115°, 120°
E (60° " ")	132° " " "	63° " " "	58°, 60°
H (120° " ")	132° " " "	117° " " "	115°, 120°
J (140° " ")	45° " " "	38° " " "	35°, 40°

In Fig. 7 stereographic projections on the *ab*, *ac* and *bc* planes show the positions of the quartz maxima as calculated from the composite *ac* curve and the *ab* curve for vein 3.

(b) *Fabric in Specimen No. 4489.* In this rock measurements were confined to three sections, parallel respectively to *ab*, *bc* and *ac*, cutting quartz-rich veins lying parallel to *ab*. The orientation curves are complex (Fig. 8) and the only satisfactory correlation

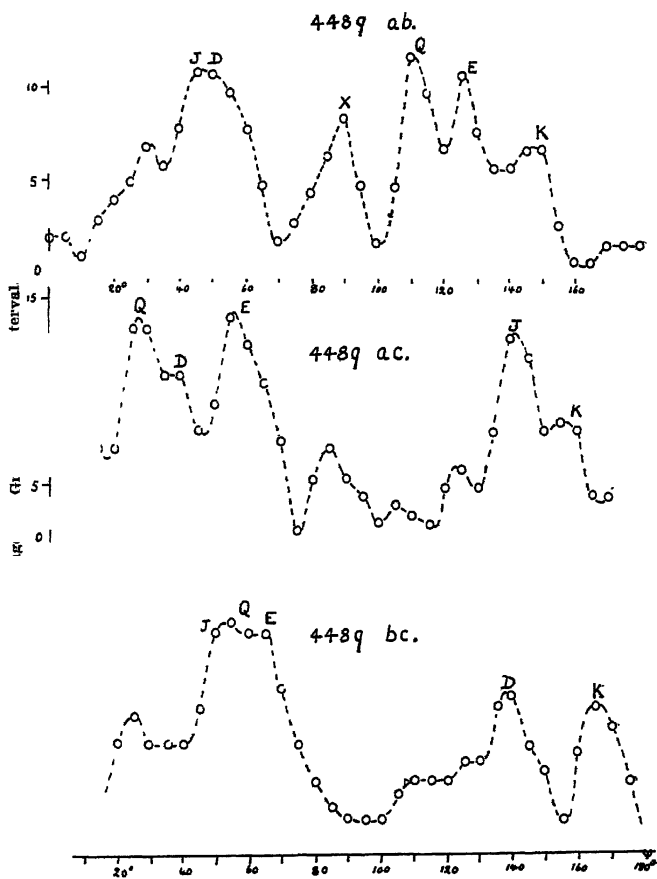


Fig. 8.—Orientation curves for quartz in veins, specimen No. 4489. Correlation of maxima in the three curves is indicated by the lettering.

4489.

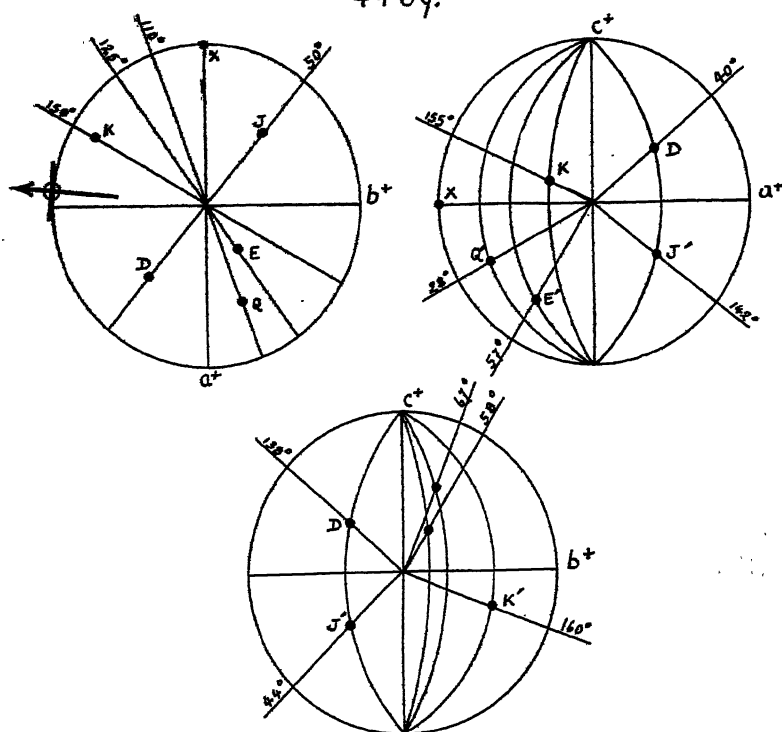


FIG. 9.—Stereographic projections upon ab , ac and bc showing positions of maximum concentration (solid circles) of quartz axes (Z) in No. 4489. The ab and ac projections are plotted directly from corresponding curves in Fig. 8. The maxima in the bc projection were determined graphically from the other two. Lettering corresponds with that in Fig. 8.

of the various maxima is that summarised in Table II below. In this the third column gives the positions of maxima in the bc curve as calculated graphically from data recorded in the curves for ab and ac . In Fig. 9 the same correlation is represented in the form of stereographic projections upon ab , ac and bc .

TABLE II.

Maximum in ac curve.	Correlated Maximum in ab curve.	Estimated Maximum in bc curve.	Observed Maximum in bc curve.
Q (28° from a)	110° from b	58° from b	25°
E (58° " ")	125° " " "	67° " " "	
J (140° " ")	50° " " "	44° " " "	50°-65°
D (40° " ")	50° " " "	138° " " "	
K (155° " ")	150° " " "	160° " " "	138°
			165°

The point X in the ab curve is correlated with the slight concentration of quartz axes parallel to a in the ac curve. This is borne out by the minimum at 90° to b in the bc curve.

(c) *Significance of the Quartz Fabric.* The quartz veins must obviously be younger than the schistosity since this latter structure has determined their orientation parallel to ab . The fabric of quartz veins will therefore be determined by late movements operating upon an original growth fabric. In movements of this type, in an already schistose rock, shearing parallel to the direction of schistosity may be assumed to predominate. Consequently the present orientation of quartz grains in sections cut parallel to ab should give some indication of the directions in which movement took place during the latest stages of metamorphism. Comparison of the ab curves for veins in both rocks described above shows the existence of maxima at angular distances of 45° , 50° – 60° , 90° , 110° and 125° – 132° from the positive end of the b axis (measured in an anticlockwise direction). The maxima that occur most consistently are those at 45° , 50° – 60° and 125° – 132° , and it will be noted that the position of the points D, E and J by which they are determined are almost identical in the two rocks. They may have originated as the result of shearing movements operating parallel to ab in directions inclined at 45° , 50° – 60° and 125° – 132° to b , i.e. across N.E.–S.W. and N.W.–S.E. tectonic axes respectively.

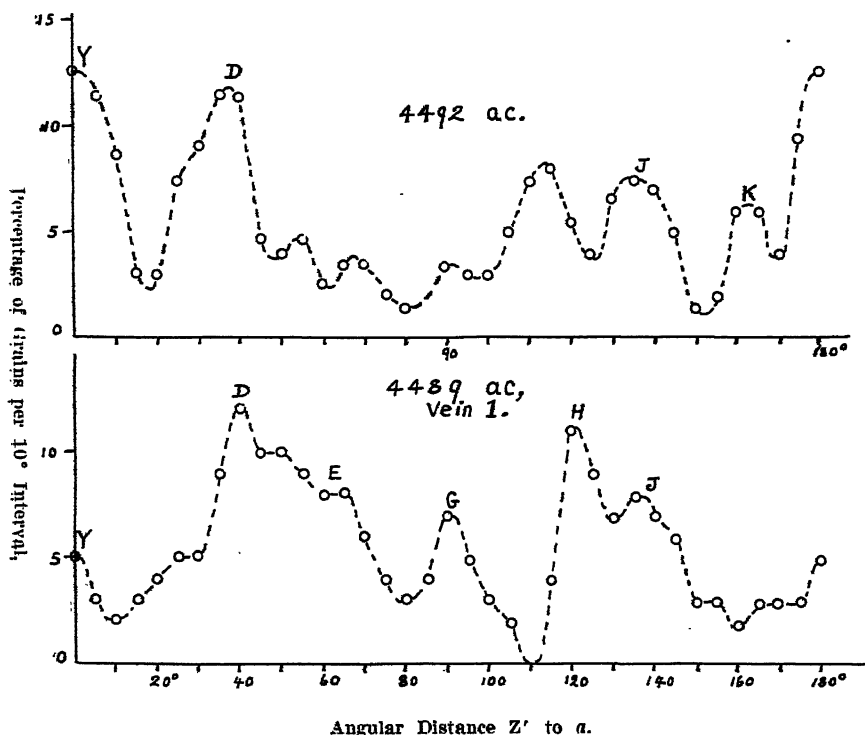


FIG. 10.—Orientation curves for quartz in ac sections of No. 4492 and Vein 1, No. 4487. Note the maxima Y parallel to a . Lettering corresponds to that in Figs. 4 and 8.

Disturbance of the original growth-fabric has been so great that the latter is difficult to reconstruct. Certain significant features may still be detected however, viz. :—

(1) Very strongly marked minima parallel to b in all bc curves.

(2) Occasional development of submaxima parallel to a in ac curves (e.g. for vein 1 in No. 4487; also in No. 4489). In the ac curve for a single vein measured in No. 4492 there is a strong maximum parallel to a (Fig. 10).

(3) Presence in ab curves of certain veins from Nos. 4487 and 4489, of maxima perpendicular to b and b' (i.e. at 90° and 105° – 110°). These are especially marked in a vein of unusual thickness (vein 5 in 4487) in which later movements have been insufficient to allow development of the maxima at 40° – 60° so consistently shown by all other curves (Fig. 6).

(4) Occurrence of submaxima parallel to c in several ac curves and in a single bc curve (No. 4492).

This last feature is considered to represent a survival of the original fabric in which growth of quartz crystals took place perpendicularly to the vein-wall, i.e. with Z parallel to c . Items (2) and (3) above are interpreted as characters imposed upon the growth fabric by the influence of crystals in the vein-walls oriented with Z perpendicular to b and b' .^{*} If the veins are younger than the schistosity, i.e. than the development of the directions b and b' in the rock fabric, no other interpretation is possible especially as the maximum perpendicular to b' (the older of the two lineations) is much more prominent in the vein fabric than is that perpendicular to b .

TECTONIC CONSIDERATIONS.

The following principal stages are recognised in the tectonic history of the Waipori schists as deduced from the fabric data recorded in this paper:—

(1) Development of a vertical set of S-planes in a sedimentary series, probably by isoclinal folding; direction of tectonic axis (b'), 20° W. of N.

(2) Horizontal shearing giving rise to the present schistosity (ab) and the main lineation (b); contortion followed by almost complete obliteration of early S-planes; local development of phyllonitic bands along zones of most intense movement; direction of tectonic axis (b), 5° W. of N. The principal joint-system with a trend of 75° – 80° E. of N. is correlated with this movement.

(3) Growth of horizontal quartzose veins parallel to the schistosity and located especially along surfaces of strong differential movement.

(4) Late deformations of minor intensity affecting the quartz fabric profoundly, but having no influence on the mica fabric.

^{*} Growth from anisotropic blastetrites (cf. Fairbairn, 1937, pp. 118, 119).

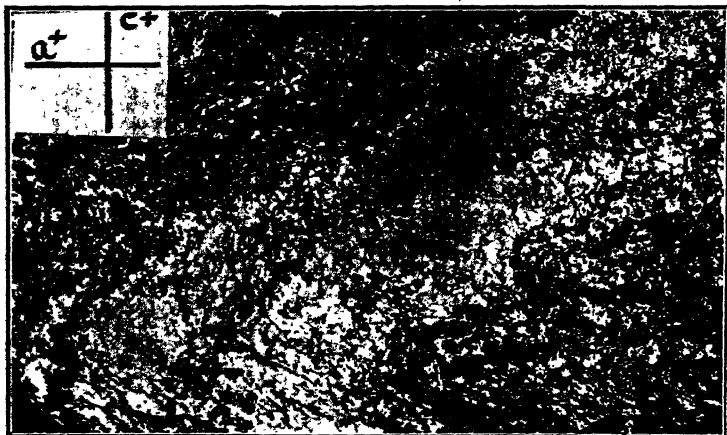


FIG. 11.—No. 4487, section perpendicular to b , showing contorted early S-planes (probably the original bedding). Magnification: 16 diameters.

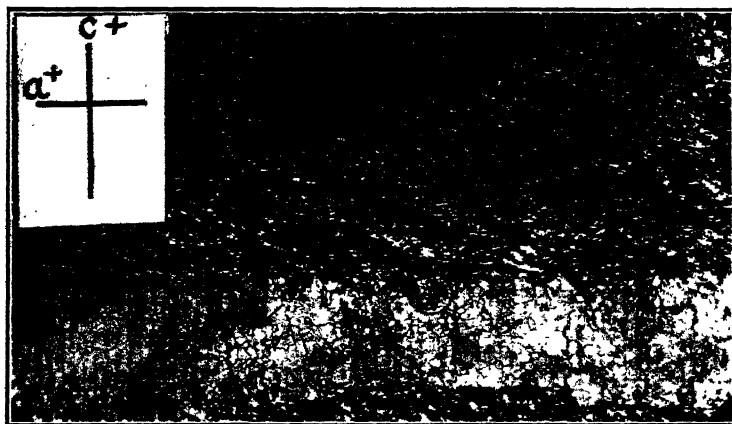


FIG. 12.—No. 4487, section perpendicular to b , showing early S-planes cut by quartzose vein parallel to ab . Magnification: 16 diameters.

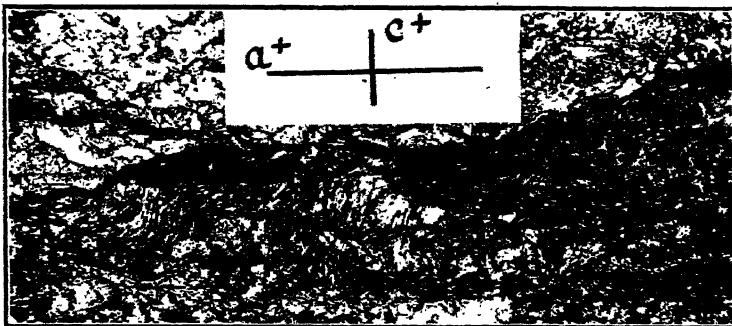


FIG. 13.—No. 4489, section perpendicular to b . In the centre of the photograph mica oriented subparallel to c preserves the direction of the early S-planes (probably the original bedding). Magnification: 16 diameters.

(a) Trend of tectonic axis, N.W.-S.E.; correlated features of the fabric are the prominent N.E.-S.W. joints (40° - 50°) and the maximum at 125° - 132° from *b* in *ab* curves for quartz.

(b) Trend of tectonic axis, 35° E. of N. Corresponding to this movement are the maxima between 45° and 60° to *b* in *ab* curves for quartz.

There is nothing in the fabric to indicate which of these last two movements is the earlier.

In Table III a comparison is given between the directions of the tectonic axes at corresponding stages in the metamorphism of the Waipori schists and the three rocks from Patearoa described in my last paper. The close agreement between the two sets of data supports my previous conclusion that in the Patearoa rocks the contorted *bc* quartz veins are relics of an ancient structure that preceded development of the present schistosity and lay approximately at right angles to the latter.

TABLE III.

Stage of Metamorphism.	Waipori.	Patearoa.
(1) Close folding	20° W. of N.	15° - 25° W. of N.
(2) Development of Schistosity (main metamorphism) ..	5° W. of N.	15° - 25° W. of N.
(3) Late movements—(a)	N.W.	N.W.
(b)	35° E. of N.	10° - 25° E. of N.

Directions of Tectonic Axes at Corresponding Stages of Metamorphism at Waipori and Patearoa.

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The Metamorphic and Plutonic Rocks of Lake Manapouri, Fiordland, New Zealand—Part III.

By F. J. TURNER, University of Otago.

[Read before the Otago Branch, April, 1937; received by the Editor, February 5, 1938; issued separately, June, 1938.]

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The Trondhjemitic Granites and Associated Gneisses.
The Pomona Island Granite and Associated Gneisses, etc.
Structure and Tectonics.
Fabric Analysis of Foliated Pomona Granite.
Acknowledgements.
Literature Cited.

INTRODUCTORY SUMMARY.

IN the first two papers of this series. (Turner, 1937, 1937a) an account was given of the metamorphic and intrusive rocks exposed in the northern, western and central portions of Lake Manapouri. Subsequently, with the assistance of a grant from the research funds of the Australian and New Zealand Association for the Advancement of Science, the writer has been able to complete the survey of the pre-Tertiary rocks of Manapouri by field work along the shores of South and Hope Arms and the intervening southern coast of the lake (Fig. 1). This paper embodies the results obtained during this later work, together with a summary of the structural features of the area as a whole.

That part of the lake here mapped lies mainly within the Eastern Manapouri Province as defined in Part I. and the rocks there exposed fall within the same stratigraphic units as described earlier, viz. (in order of decreasing age): (a) basal gneisses (Holmwood Island Gneisses), correlated with Professor Park's Dusky Sound Series; (b) Beehive epidiorite; (c) Pomona Island granite and hybrid derivatives; (d) Tertiary sandstones and conglomerates. However the white trondhjemitic granites of the Western Province, accompanied by minor amounts of the invaded basement gneiss, are exposed continuously along the west shore of South Arm, and there form the eastern margin of the great injection-complex described in Part 2. Nowhere has the trondhjemitic granite been observed in contact with either the epidiorite or the Pomona Island granite, so that the relative age of the three groups of rocks remains rather uncertain (cf. Turner, 1937a, pp. 244, 245).

THE TRONDHJEMITIC GRANITES AND ASSOCIATED GNEISSES.

Along the western shores of South Arm granitic rocks greatly preponderate over the invaded gneisses, the occurrence of which is limited to large blocks often several yards in diameter enclosed locally in the intrusive member of the complex.

The latter is a white, rather fine-grained often gneissic rock usually conforming to the composition of "oligoclase-granite" as previously described (Turner, 1937a, p. 232). A typical specimen (No. 4505) consists of acid oligoclase 50% to 60%, interstitial sometimes coarsely crystalline microcline 10% to 15%, quartz 20%,

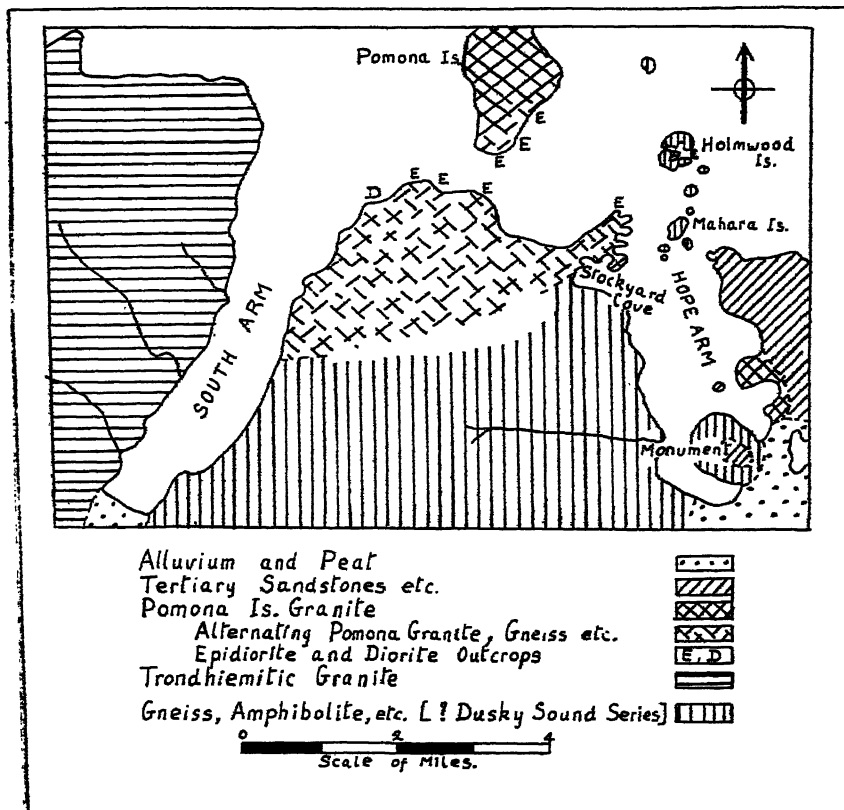


FIG. 1.—Geological Map of the Southern Portion of Lake Manapouri.

brown biotite 8%, and accessory muscovite, apatite and epidote. Myrmekite is present at microcline-plagioclase junctions while the quartz and some grains of feldspar show undulose extinction. Occasionally (e.g. No. 4508) microcline may make up as much as 50% of the composition and the rock may then be classed as a microcline-granite. Typical trondhjemites are absent in this sector.

The invaded gneisses are oligoclase-quartz-hornblende-biotite-gneisses, generally similar to those described in Part 2 (p. 228) but poorer in the dark constituents and usually containing a considerable quantity of quartz. A typical composition (No. 4507) is plagioclase 60%, quartz 15%, hornblende 15%, biotite 10%, epidote 1%, accessory sphene, apatite and zircon. Occasionally there are lighter-coloured bands in which biotite predominates over hornblende (No. 4510), and in one case (No. 4509) quartz is almost absent. The plagioclase is usually medium oligoclase, ranging from Ab_{82} to Ab_{72} ;

it occurs in equant, for the most part untwinned grains, which often show incipient alteration to sericite. In several sections (e.g. Nos. 2506, 2509) crystals of plagioclase may enclose scattered minute segregations of microcline. The biotite is a yellowish brown variety, usually partially chloritised, and in some cases is associated with aggregates of flaky prehnite (Nos. 4506, 4510). The hornblende invariably shows the intense pleochroism and deep blue-green absorption for vibrations parallel to Z, that characterise the amphibole of corresponding gneisses throughout the western injection-complex. Epidote is never as plentiful as in the rocks described in Part 2, but is the same colourless strongly birefringent type ($\gamma-\alpha = 0.035-0.04$), and often encloses vermicular quartz; in some sections (e.g. No. 4510) it is associated with strongly pleochroic allanite (X = very pale yellow, Z = deep brown; $\gamma-\alpha = 0.015$). The sphene and apatite are coarse and always abundant. Zircon is rare (No. 4507).

As in other parts of the western injection-complex signs of assimilative reaction between magma and gneiss are few. Possibly to be attributed to this process are such unimportant details as the presence of minute quantities of potash-feldspar, slight sericitisation of plagioclase and development of allanite and prehnite in the invaded rocks. In no case is there any indication of replacement of hornblende by biotite.

THE POMONA ISLAND GRANITE AND ASSOCIATED GNEISSES, ETC.

(a) *The Invaded Gneisses.*

Eastward from the head of South Arm to the western border of the Tertiary covering strata, the ancient gneisses* previously correlated with the Dusky Sound Series are the dominant rocks, though broken at intervals by tongues of Pomona Island granite. Interruption of this sort is least within two miles of the head of the South Arm, and again along the western shore of Hope Arm south of Stockyard Cove.

Two broad lithological divisions may conveniently be distinguished, viz., coarse-grained gneisses and finer dark-coloured amphibolites, though there is considerable variation in each group. Certain features are common to the rocks of both groups, especially the universal association of plagioclase (acid oligoclase to mediana andesine) with green hornblende, biotite or both minerals, and the constant abundance of sphene and apatite as accessory constituents. Rough foliation may usually be observed, and is parallel to the bedding when the latter is recognisable.

The most widely developed members are coarse hornblende-plagioclase-biotite-gneisses, often containing between 10% and 20% of quartz and small amounts of colourless highly birefringent epidote. Many of these rocks are closely similar to gneisses of the Western Province and from the area on the north coast of the lake opposite Pomona Island (cf. Part 1, pp. 95, 96; Part 2, pp. 227, 228). Typical examples are described briefly below:—

* These belong to the same group as the gneisses invaded by trondhjemitic granite further west.

No. 4512 (East coast of South Arm, 1 ml. from head; widely distributed). A coarsely gneissic rock with average grain-size of 3 mm. The composition (estimated by inspection) is blue-green hornblende 20%, biotite 20%, oligoclase 50%, quartz 5%, epidote 5%, abundant sphene and apatite. The biotite is partly chloritised, and also shows replacement by aggregates of prehnite.

Nos. 4546 and 4547 (South side of first small bay inside western headland at entrance to Hope Arm) represent light and dark bands of the same hand-specimen. Fine-grained dark material (No. 4547), comparable in composition and structure with the amphibolites, predominates. This consists of hornblende 35%, biotite 15%, medium andesine 40–45%, epidote 5%, sphene 1%, iron-ore 1%, and accessory apatite. The average grain-size is 0.5 mm., but there are occasional large feldspars 4 mm. across; much of the feldspar shows albite twinning, an unusual feature in rocks of this type. While much of the hornblende is the usual blue-green type, there is also a variety having deep greenish-brown for the Z vibration-direction. Light-coloured bands in the same rock (No. 4546) contain less hornblende and only minor biotite. The amphibole is in coarse ragged crystals with marked sieve-structure, the central portions of which may be bleached to pale-green or almost colourless.

Nos. 4550 and 4551 (Western shores of Hope Arm) are plagioclase-hornblende-biotite-gneisses of finer grain, resembling the predominating rocks of Holmwood and adjacent islands (cf. Part 1, pp. 84, 85). Sphene is plentiful and pyrite usually is present, while in No. 4451 there is about 15% of quartz. On the southern side of Stockyard Cove they give place to very coarse gneisses of dioritic aspect (No. 4548) consisting of oligoclase-andesine, coarse biotite, sieved green hornblende and accessory apatite and sphene.

Associated and interbedded with the hornblende-bearing rocks are gneisses containing little or no amphibole, typical examples of which are described below:—

No. 4543 (South shore half-way between South and Hope Arms) is a rather fine-grained rock consisting of untwinned basic oligoclase and biotite in subequal proportions, accompanied by minor colourless epidote, relatively abundant granular sphene and accessory apatite. The biotite is a greenish-brown variety. The rock occurs as a constituent of large masses completely surrounded by Pomona Island granite. Interbedded with it are a hornblende-plagioclase-gneiss with little biotite (No. 4542) and a coarse gneissic rock of most unusual composition consisting almost entirely of biotite and epidote (No. 4541). In the latter rock, the epidote is the usual colourless highly birefringent type and makes up about 60% of the total composition. The biotite is deep greenish brown (Z) to pale yellow (X). Accessories include sphene, apatite, pyrite and occasional aggregates of sericite enclosed in the epidote.

No. 4553 (West coast of Hope Arm, 1½ mls. from head). An unusually light-coloured phase, interbedded with plagioclase-biotite-gneiss (No. 4552) and plagioclase-quartz-hornblende-biotite-gneiss (No. 4551). The composition is oligoclase 50%–60%, quartz 30%–40%, biotite 5%, coarse granular colourless epidote 5%, accompanied

by sphene, apatite and much pyrite as accessories. The biotite is intensely pleochroic from pale yellow to deep red-brown, in contrast with the greenish-brown tint of the mica in associated rocks. It is partially replaced by colourless chlorite. An unusual feature shared also by the associated plagioclase-biotite-gneiss is the presence of small amounts of interstitial highly irregular orthoclase.

Along the eastern shore of South Arm, from the entrance to a point about 3 mls. from the head, the predominating members of the gneissic series are fine-grained, dark-green amphibolites of almost hornfelsic aspect (Nos. 4513, 4514, 4516, 4520, 4530, 4534). Small masses of contaminated epidiorite are associated with these rocks near the entrance to the Arm, and throughout their whole extent interruption by extensive outcrops of granite is frequent. Full petrographic descriptions are unnecessary since there is a close mineralogical resemblance to the amphibolites from Holmwood and other islands as already described (Part 1, p. 85). The main constituents are plagioclase (usually andesine) and deep blue-green hornblende in about equal quantity, accompanied by accessory epidote, sphene, iron-ore and apatite. Reddish-brown biotite may be present in small quantities (e.g. Nos. 4520, 4534), and in one case (No. 4534) the percentage of epidote is as high as 10%. Patches of well crystallised prehnite were noted in a single section (No. 4513). Slender prisms of yellow rutile are very plentiful in No. 4519. Pyrite was observed in most sections. In contrast with the amphibolites described in Part 1, the rocks from the South Arm usually show perfect parallelism of the hornblende crystals, which typically are prismatic and idioblastic. In this respect they may closely resemble certain of the hornblende-schists that occur on Pomona Island as major inclusions surrounded by granite (Part 1, pp. 93, 94).

(b) *Basic Intrusive Rocks.*

From a point about $\frac{1}{2}$ ml. inside South Arm to the headland at the entrance of Hope Arm, basic intrusives predominate among the rocks invaded by the granites, and are associated with various members of the basement gneiss series. Some are indistinguishable from rocks outcropping on Pomona Island and the northern shore of the lake, and shown in Part 1 (pp. 90-92) to be contaminated phases of the Beehive epidiorite; others, while still retaining traces of igneous structure, have no counterpart among rocks previously described from Manapouri. There are also one or two specimens of doubtful origin, which should perhaps be included with the hornblende members of the ancient gneissic series (e.g. No. 4539).

Many of the amphibolites already described are probably derivatives of basic lavas or tuffs (cf. Part 1, p. 86), and it is even possible that some of the rocks classed above as amphibolites may in reality be completely reconstituted members of the epidiorite group. The difficulty in making a sharp distinction arises from the fact that regional metamorphism of the ancient lavas and tuffs and partial granitisation of the epidiorites both lead to the development of the mineral assemblage oligoclase-hornblende-biotite-sphene-epidote. In the amphibolites the original structure has been obliterated and a crystalloblastic structure substituted. In the contaminated

intrusives, however, the original structure tends to be preserved in part, and especially the coarse tabular crystals of plagioclase usually retain their habit even though changed in composition. In all except a few doubtful cases therefore, amphibolites and contaminated epidiorites may be distinguished on grounds of structure.

Typical contaminated epidiorites are represented by Nos. 4532 (5 ch. E. of entrance to South Arm), 4535 (25 ch. E. of entrance to South Arm) and 4544 (headland at western side of entrance to Hope Arm). Coarse tabular plagioclase (medium to basic oligoclase) sometimes enclosing clusters of epidote prisms makes up 50% to 60% of the composition. Deep green hornblende is plentiful, but in more altered rocks (e.g. No. 4532) tends to be replaced by aggregates of flaky biotite, while the remaining crystals develop pronounced sieve-structure. The percentage of biotite varies from 10% to 30%. Sphene and apatite are exceedingly plentiful. The former characteristically occurs as granular rims surrounding grains of iron-ore, or else as rounded aggregates with roughly radial structure resulting from complete replacement of that mineral. Epidote is a minor constituent. In No. 4544 nests of granular quartz make up 10% of the composition and there are small amounts of interstitial orthoclase. Locally the structure may be considerably modified by shearing (No. 4533). The above rocks are all invaded or surrounded by the Pomona Island granite or its contaminated derivatives.

A somewhat different type of basic intrusive rock, probably belonging to the epidiorite series, occurs in association with amphibolite and granite at a point about half a mile inside South Arm (Nos. 4528, 4529). No. 4528 is a holocrystalline rock composed principally of long prisms of hornblende (40%) and equidimensional twinned grains of plagioclase (50% to 60%). Minor constituents are pyrite, coarsely crystalline chlorite (optically +, biaxial) and apatite, together making up about 5% of the composition. The plagioclase is a medium andesine and locally is altered to kaolin or sericite. The hornblende occurs in poorly terminated subidiomorphic prisms (1 mm. \times 0.5 mm.) with strong pleochroism as follows:—

X = pale yellow
Y = deep yellowish-green
Z = deep blue-green
 $Z > Y > X$.

The extinction angle Z to $c = 17^\circ$. The central portions of the grains are crowded with schiller inclusions. No. 4529 is obviously related to the rock just described, but is finer in grain and contains about 5% of pale biotite. Local recrystallisation has considerably reduced the grain-size. Both rocks may be classed as diorites. From their field association with an amphibolite (No. 4530) of similar mineralogical composition but with no trace of igneous structure it is possible that all three rocks have a common origin. Alternative grouping with the epidiorites is preferred by the writer however.

(c) *Pomona Island Granite.*

Extensive outcrops of granite of the Pomona Island type occur at frequent intervals along the eastern side of South Arm from a point about three miles from the head to the entrance, and thence eastward along the southern shore of the lake to Hope Arm. The individual outcrops are often five or ten chains in width, and alternate with equally extensive exposures of gneiss and epidiorite. Toward the head of South Arm the granites are represented only by sparsely distributed pegmatitic and aplitic dykes cutting the gneiss. Granites are well developed in Hope Arm only around Stockyard Cove and again on the eastern shores on a small peninsula half a mile north of the Monument. Also in one or two places on the western shore of Hope Arm massive pegmatitic dykes invade the prevailing gneiss.

In composition representative specimens (Nos. 4523-4525, 4527, 4538, 4540) are similar to the Pomona Island granites described in Part 1 (p. 89): microcline, albite-oligoclase and quartz are about equally plentiful, while the dark constituents together total less than 5% of the composition. In structure there are certain differences however. Typically there is definite foliation due partly to segregation of quartz into narrow lenticles and partly to parallel development of streaky aggregates of dark minerals; this will be discussed more fully in the section dealing with fabric analysis. The quartz is coarse-grained and undulose. The habit of the feldspars varies. In most specimens from South Arm (e.g. Nos. 4523-4525) small grains of microcline and plagioclase (0.2 mm. in diameter) enclose a few larger crystals of both minerals, those of plagioclase being charged with epidote or sericite. In No. 4540 (halfway between South and Hope Arms) coarse composite crystals composed of microcline and oligoclase in subequal proportions are accompanied by a few large grains of oligoclase alone. In other instances (e.g. No. 4538) clear coarse grains of perthitic microcline and cloudy crystals of oligoclase often riddled with small flakes of sericite occur independently. The range of structures suggests that in some cases microcline and plagioclase have crystallised independently while in others microcline has replaced crystals of plagioclase at a late stage.

The dark streaks observed in the hand-specimen in most cases are aggregates of black opaque iron-ore, very strongly coloured chlorite, sphene and epidote. The chlorite is uniaxial, negative and intensely pleochroic; $X = \text{yellow}$, $Y = Z = \text{very deep green}$. Apparently it is a product of hydrothermal alteration of biotite, for residual flakes and laminae of that mineral were noted in association with chlorite in one section (No. 4538). The sphene often mantles the grains of iron-ore but also occurs as independent rounded crystals. Allanite with intense pleochroism from pale yellowish-brown to deep red-brown is often associated with the epidote. In some rocks aggregates of muscovite and chlorite or muscovite, iron-ore and minor chlorite also occur (Nos. 4527, 4540). Comparison with the contaminated granites of Pomona Island (Part 1, p. 99) suggests that these dark composite streaks are largely of xenolithic origin, derived from the disintegration of granitised epidiorite and amphibolite.

The aplites and pegmatites associated with the Pomona Island granite are normal rocks worthy of only brief comment. The former (Nos. 4521, 4522) consist largely of oligoclase and quartz, with small quantities of biotite and accessory chlorite, muscovite, epidote and apatite. The pegmatites are coarse-grained rocks in which perthitic microcline, medium oligoclase and quartz are the main constituents; accessories include biotite, muscovite, apatite and sphene. Crystals of the two varieties of feldspar seem to be quite independent.

(d) *Contaminated Derivatives of Granite Magma.*

Intrusive rocks believed to be contaminated derivatives of the granite magma were collected from three localities. These occurrences are described separately below so that the evidence bearing on petrogenesis may be recorded fully.

The most southerly mass of Pomona granite exposed in South Arm forms an extensive outcrop about 15 to 20 chains in length flanked on either side by amphibolite, about 3 mls. from the head of the arm. The typical granite collected from the middle of this outcrop (No. 4515) is much poorer in potash-feldspar than the normal Pomona granites. The main constituents are coarse albite-oligoclase (enclosing much epidote and sericite) 60%–70%, orthoclase with local microcline structure 10%; quartz 15%, chloritised biotite 5%, and epidote 5%. Allanite, apatite and pyrite are accessories. An unusual feature is the presence of pinkish garnet in highly irregular granular masses between the boundaries of the large feldspars. Border phases collected at the northern contact are coarse blotched rocks of dioritic appearance (Nos. 4517, 4518). No. 4517 differs from the granite just described in complete absence of potash-feldspar, greater abundance of chloritised biotite (10%) and the presence of plentiful green hornblende (20%). The biotite is almost completely replaced by chlorite and prehnite, and grains of iron-ore enclosed in the hornblende crystals are rimmed with granular sphene. In composition the rock is a tonalite. No. 4518 appears to be a typical diorite composed essentially of medium andesine (90%) and coarse blue-green hornblende (10%). Accessories include black iron-ore, biotite, epidote and apatite.

About five chains east of the entrance to South Arm a coarsely blotched rock (No. 4531) of rather similar composition occurs as fairly extensive masses invading contaminated epidiorite and enclosing major inclusions of amphibolite. Plagioclase approximating to oligoclase-andesine makes up 75% of the rock. The remainder consists of aggregates of coarse blue-green hornblende in all stages of replacement by intensely pleochroic yellowish-brown biotite. These aggregates enclose coarse prisms of apatite and large grains of iron-ore rimmed with granular sphene. In the duplicate section from the same hand-specimen (No. 4531a) replacement of hornblende by biotite is complete and the biotite itself has locally been altered to chlorite.

Rather similar rocks occur again halfway between the entrances to Hope and South Arms, as masses 50 yds. in width alternating with contaminated epidiorite. Of these No. 4537 resembles No. 4531a in consisting almost entirely of medium oligoclase (75%) and deep

yellowish-brown biotite (25%). The latter occurs in aggregated masses enclosing granular sphene, iron-ore and apatite. Small amounts of quartz occur in nests between the crystals of feldspar. No. 4536 differs from the rock just described in the presence of residual hornblende enclosed in the biotite aggregates, and in the development of microcline and orthoclase interstitially and as patches replacing the large grains of plagioclase. The latter enclose a good deal of epidote and sericite. Quartz is absent.

In considering the genesis of the rocks just described certain additional facts must be borne in mind: (a) in all cases the rocks in question definitely bear an intrusive relation to the amphibolites and epidiorites; (b) exposures of typical Pomona Island granite occur at intervals between the three localities enumerated above; (c) the coarse hornblende of the "dioritic" rocks seems in all cases to be a primary product of magmatic crystallisation and could not have been derived from the adjacent amphibolites and epidiorites by marginal disintegration of these rocks; (d) the proportion of dark constituents to plagioclase is much too low to allow the possibility of derivation by contamination of rocks of the epidiorite group. It is therefore suggested that the "dioritic" rocks such as Nos. 4518 and 4531 are products of crystallisation of a locally contaminated magma derived from the parent Pomona granite magma as a result of reaction between the latter and the invaded rocks (cf. Part I, p. 99). Replacement of hornblende by biotite, introduction of quartz, and in one case late crystallisation of microcline at the expense of earlier-formed plagioclase are attributed to the action of residual potassic silica-rich liquids emanating from the adjacent relatively uncontaminated granitic magma. The microcline-poor granite (No. 4515) associated with dioritic hybrids in South Arm is the product of crystallisation of a granite magma in the earlier stages of contamination when potash was being removed progressively to allow conversion of hornblende to biotite in adjacent rocks (cf. Part I, p. 99).

Elsewhere in the contact zone of the granite intrusion marginal reaction has affected the bulk composition of the magma to a less extent, and microcline-rich granites containing plentiful altered xenolithic clots of biotite, sphene and iron-ore make sharp contacts with the invaded rocks. An intermediate condition has already been described on the southern end of Pomona Island, where normal granite and altered epidiorite are separated by a zone of granite poorer in microcline and richer in xenolithic biotite than is usually the case (Part I, p. 94).

STRUCTURE AND TECTONICS.

As regards structure, the area here considered has much in common with that covered in the first two papers of this series. A summary of the structural data for the Manapouri region as a whole may therefore be presented at this point. The criteria recorded are defined as follows (for a detailed discussion of their significance see Balk, 1937; Fairbairn, 1937):—

Foliation: A streaky, lamellar or banded structure resulting from

aggregation of particular minerals into lenticles and bands. Cleavage (schistosity) is parallel to the foliation when present in Manapouri rocks.

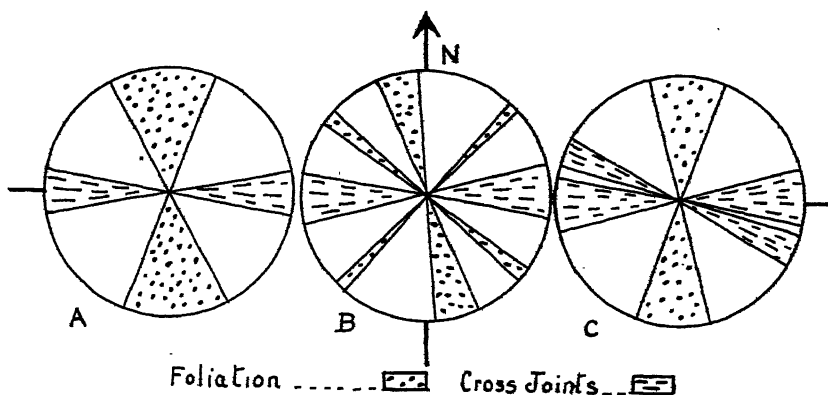
Lineation: Parallel arrangement of prismatic crystals or elongated microxenoliths with long axes in a common direction within the plane of foliation.

Cross-joints (Q-joints of Cloos, *ac*-joints of Sander): Usually vertical or steeply dipping joints perpendicular to the lineation, foliation and fold axes, i.e. to the tectonic axis.

Longitudinal joints: Approximately vertical joints striking parallel to the foliation in some plutonic rocks.

In the older gneisses (Dusky Sound Series) exposed in Hope Arm, the eastern coast of South Arm and at intervening points on the southern shore of the lake, the foliation dips steeply and strikes between 30° W. of N. and 20° E. of N. Approximately the same range of strike is recorded for rocks of this series throughout the whole Manapouri region, though there is a definite tendency for a N.N.W. trend to predominate.* Corresponding vertical or sub-vertical joints are sometimes well developed, e.g. along the western shore of Hope Arm. Two sets may be recognised, viz. cross joints striking between 80° and 100° E. of N., and less frequently longitudinal joints parallel to the foliation. All three may be correlated with movements across a tectonic axis the trend of which varies between 30° W. of N. and 30° E. of N. but frequently approximates to a mean N.N.W. direction.

The trondhjemites and related granites of the western injection-complex show considerable variation in structure. The most noticeable and consistently developed structural elements are a steeply dipping foliation and accompanying longitudinal jointing with a



A: Gneisses. B: Trondhjemites. C: Pomona Granite.

FIG. 2.—Range of foliation and cross joints in gneisses (A), trondhjemites and allied granitic rocks (B), and Pomona Island granite (C). Longitudinal joints often accompanying foliation.

strike of 5° to 25° W. of N., together with correlated cross joints

* Occasionally, for example in the vicinity of the shatter zone opposite the N.W. corner of Pomona Island, the strike locally may swing as far east as 45° E. of N.

ranging between 75° and 100° E. of N. Along the southern shore of the lake between West and South Arms, and in the latter inlet itself, foliation and longitudinal joints trending 50° to 55° W. of N. prevail, though even here the N.N.W. strike may locally assert itself. On the other hand a N.E. foliation has been observed at several points in West and North Arms. Thus for the western injection-complex as a whole the prevalent trend of the tectonic axis is N.N.W., the local deviation to N.W. or N.E. in particular areas may have a tectonic significance or on the other hand may be the result of local variation in direction of magmatic flow, a condition to be expected in the upper parts of the bathylith where roof-pendants are large and numerous.

The Beehive epidiorite is typically a non-foliated well-jointed rock, but the directions of jointing show little regularity when compared over wide areas.

In the Pomona Island granite, foliation is inconspicuous or absent except in the vicinity of contacts. Here, especially in the contact-zone of South Arm, where granite and invaded gneiss alternate rapidly for several miles along the eastern shore, a vertical foliation marked by parallel arrangement of small dark xenolithic clots and aggregations of quartz into narrow streaks is often conspicuous. In all such cases it lies parallel to the regional trend of the foliation in the adjacent gneiss. Longitudinal joints and narrow xenolithic bands of dark schist often many yards in length trend in the same direction as the foliation, and may also be observed in non-foliated massive granite far from visible contacts and in all parts of the intrusion. All these structures have therefore the same tectonic significance, and whether occurring together or alone define the plane of flow of the congealing granite magma and the tectonic axis of contemporaneous earth movements. This direction invariably lies between 15° W. of N. and 20° E. of N. Correlated cross joints with a trend of 75° to 100° E. of N. constantly occur throughout the whole mass (Fig. 2). In addition to the cross and longitudinal joints just described there may locally be a third set of subvertical joints the strike of which varies between 105° and 120° E. of N. For example, all three sets are well developed in the massive granite that outcrops continuously along the northern shore of Pomona Island. Possibly these may indicate minor movements across a tectonic axis 15° to 30° E. of N.; on the other hand they may have no obvious tectonic significance.

Special structural peculiarities characterise the Pomona granite in the contact zone of South Arm. The southern margin of the intrusion lies in the roof region where pendants of invaded rock occupy as much space as the intervening intrusive granite and its hybrid derivatives. This contrasts with the conditions observed on the northern half of Pomona Island and the opposite northern shores of the lake, where major inclusions are much more sparsely distributed and rarely exceed 20 yds. in length by three feet in maximum thickness, and the granite itself is non-foliated. In the marginal zone of South Arm a vertical foliation with a strike of 5° to 10° E. of N. is well defined in most outcrops of granite; junctions between gneiss and granite also dip steeply and frequently show the same

trend as the foliation. Here also two sets of mutually perpendicular joints dipping north and south respectively at angles of 40° to 50° are perfectly developed and share a common strike perpendicular to the tectonic axis, i.e. 95° to 100° E. of N. A marked lineation in the plane of foliation here dips southward more or less parallel to one set of joints, so that only the north-dipping set may be interpreted as cross joints (cf. Fig. 3). According to Cloos, Balk and others (e.g. see Balk, 1925, 1937) foliation and lineation in granitic rocks are primary structures developed by flow of the partially crystallised magma during the later stages of intrusion, and their directions are therefore perpendicular to the direction of contemporaneous compression. Lineation in relation to magmatic flow has been interpreted variously: near the margin of the intrusion where differential movement is strong lineation, usually dipping steeply subparallel to the contact, represents the direction of magmatic flow; but in the more central portions of the intrusive mass, where the velocity of the rising magma was subject to little lateral variation in velocity, differential movement was small and lineation therefore has developed horizontally, i.e. across the direction of flow (Fairbairn, 1937, p. 111). In the granites of the South Arm of Manapouri, lineation may safely be considered to represent direction of flow, for the dip is steep (45°) and away from the centre of the intrusion and the rocks themselves lie in the contact zone.

The northern margin of the Pomona intrusive lies in the heavily forested region beyond the northern shore of the lake and is therefore inaccessible for structural investigation.

In the first two papers of this series (Turner, 1937, p. 88; 1937a, p. 244) the Pomona Island granite was considered, from its generally massive character as displayed throughout the region then mapped, to be a late intrusion the emplacement of which occurred after compressional movements had almost ceased. Certainly the evidence of such movement is much less striking, and developed to a more limited extent, than in the older trondhjemitic-granite intrusion of the western Manapouri Province. It is now evident however from the present study that upward flow of the Pomona granite magma was affected by compressional movements acting across a N.N.W. to N. tectonic axis, an axis shared also by the invaded gneisses and the trondhjemitic rocks alike during their deformation. Since only a part of the Pomona intrusion is exposed around the lake shores it is impossible to reconstruct its detailed structure. But the nearly vertical disposition of the cross joints throughout the main mass, in contrast with their inclined orientation and the complementary southward dip of the lineation near the southern margin, suggests an arched arrangement of flow-lines such as has commonly been observed in bathylithic masses forced upward under pressure during the closing stages of orogeny (cf. Balk, 1937, pp. 69–86). This reconstruction of the conditions accompanying the uprise of the Pomona granite magma accords with the generalisations recently summarised by Bucher (1933, pp. 285–290), e.g.: "Observation teaches us that as far back as the record is clear, granite magmas had accumulated in sufficient size to rise effectively in the crust only by the time that orogenic stress was diminishing" (p. 289). "On

the other hand Cloos' detailed studies have proved that the regional stress had not completely ceased while most granitic intrusive bodies studied by him rose to their final lodging place. He could show that generally the direction of 'stretching,' that is, the direction of drawing out and thinning out of the solidifying magma recorded by the parallel orientation of linear elements among the crystals and inclusions, is quite independent of irregularities of shape of the intrusive body. This remarkable uniformity in the inner texture must be due to the regional stress which ultimately caused and controlled the discordant uprise of the magma. In most cases this regional stress has the same direction as that which produced the last folding" (p. 286). Petrofabric analysis shows that the same compressional forces continued to operate even after the Pomona granite magma had completely solidified.

FABRIC ANALYSIS OF FOLIATED POMONA ISLAND GRANITE.

For investigation of the microfabric of the Pomona Island granites a well foliated specimen from the southern contact zone was selected.* The megascopic data (cf. Fig. 3a) are as follows:—

Foliation (*ab*) vertical; strike 5° E. of N. Rift (direction of easiest cleavage) parallel to foliation.

Lineation (*b*) dips southward at 45° . Cross joints (*ac*) strike 95° E. of N. and dip northward at 45° .

Joints subparallel to *bc* well developed; strike 95° E. of N.

Polished surfaces of the hand-specimen show that the foliation is due principally to aggregation of quartz into discontinuous foliae about 0.5 mm. to 1 mm. in thickness, which are more clearly defined on the *bc* than on the *ac* surface. Flattened aggregates of flaky

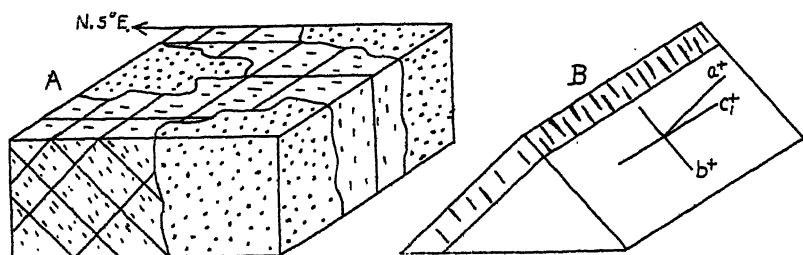


FIG. 3.—A. Diagram showing structural features of granite (represented by specimen No. 4525) halfway along east coast of South Arm; invaded amphibolite and gneiss indicated by dotted areas (the actual exposures are often 100yds. in width). Joints in granite are indicated by full lines; broken lines represent lineation. Foliation vertical, parallel to plane of the page. B. Section block showing relative positions of *a*, *b* and *c* axes in relation to lineation and foliation. Directions in A and B correspond.

chlorite and granular iron-ore of xenolithic origin, not exceeding 1 cm. in length, lie with their greatest dimensions parallel to the foliation. As seen on *ab* and *bc* surfaces they are arranged along "flow lines" parallel to *b* thus clearly defining the latter direction.

In section the principal constituents are sodic oligoclase, quartz, microcline and chlorite. Both feldspars build up a mosaic of small

* No. 4525, east shore of South Arm $3\frac{1}{2}$ to 4 mls. from head of Arm.

grains averaging 0.2 mm. in diameter, in which larger tabular crystals (1 mm. to 1.5 mm.) are enclosed; the latter tend to lie parallel to the foliation. Quartz occurs mainly as relatively coarse crystals (0.5 mm. to 2 mm.) concentrated in streaks and lenticles trending parallel to *ab*, but is also represented by small grains in the feldspar mosaic. Undulose extinction is almost universal and is developed on a perfect scale. Closely spaced cracks and lines of dusty inclusions oriented parallel to *ac* are clearly observable in *ab* and *bc* sections.

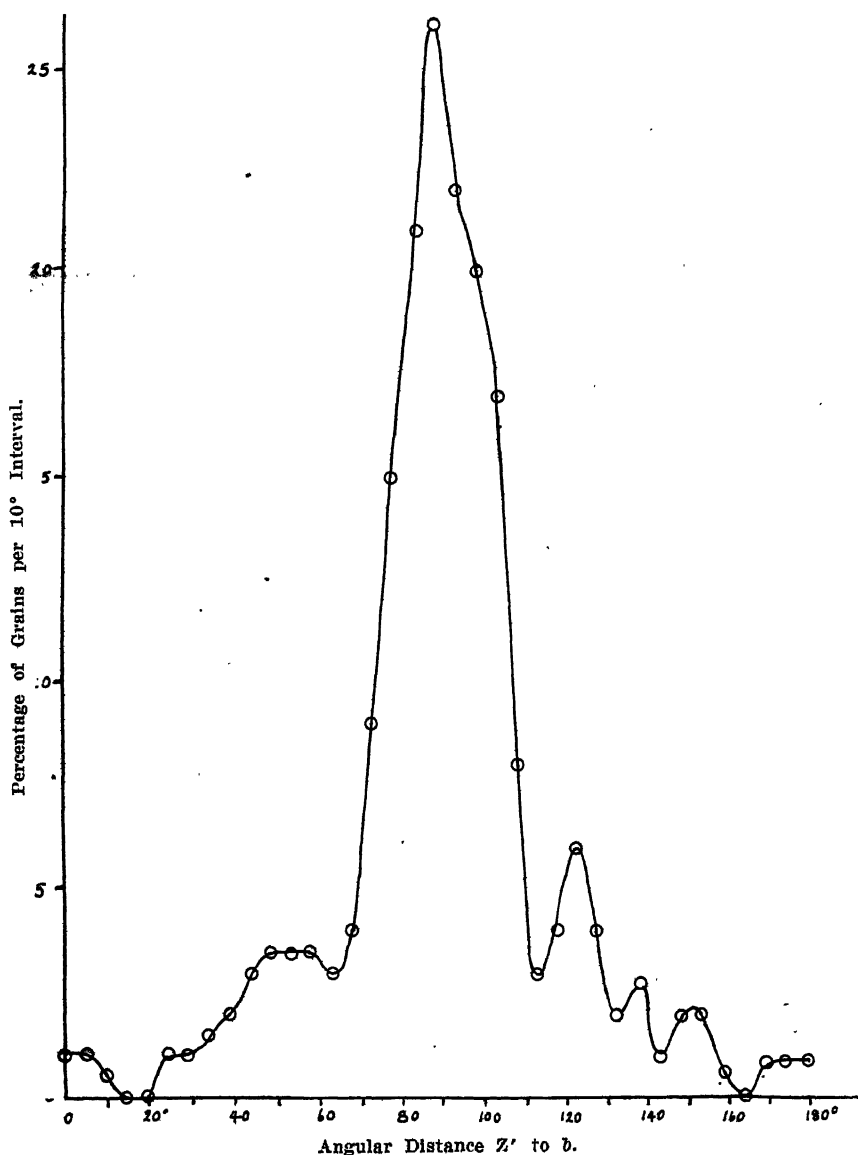


FIG. 4.—Orientation curve for quartz in *ab* section of specimen No. 4525 (375 grains).

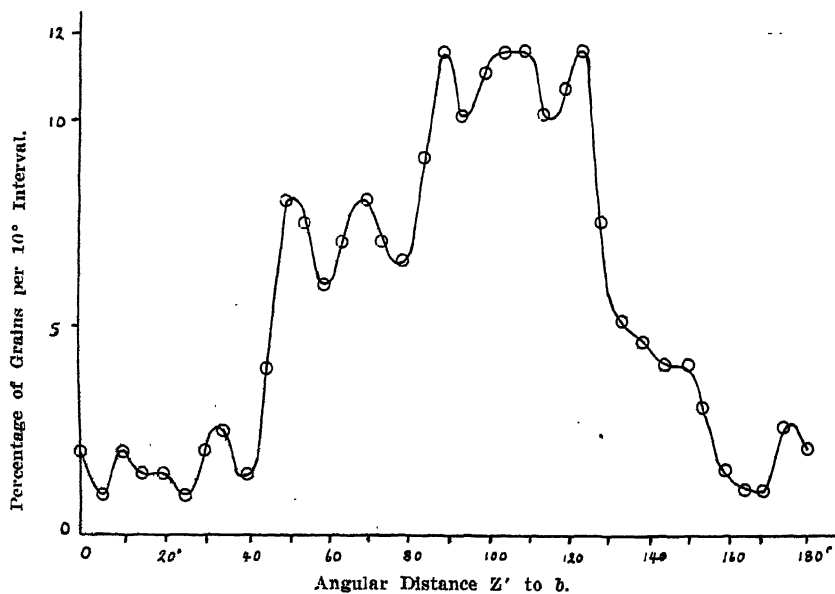


FIG. 5.—Orientation curve for quartz in *bc* section of specimen No. 4525 (500 grains)

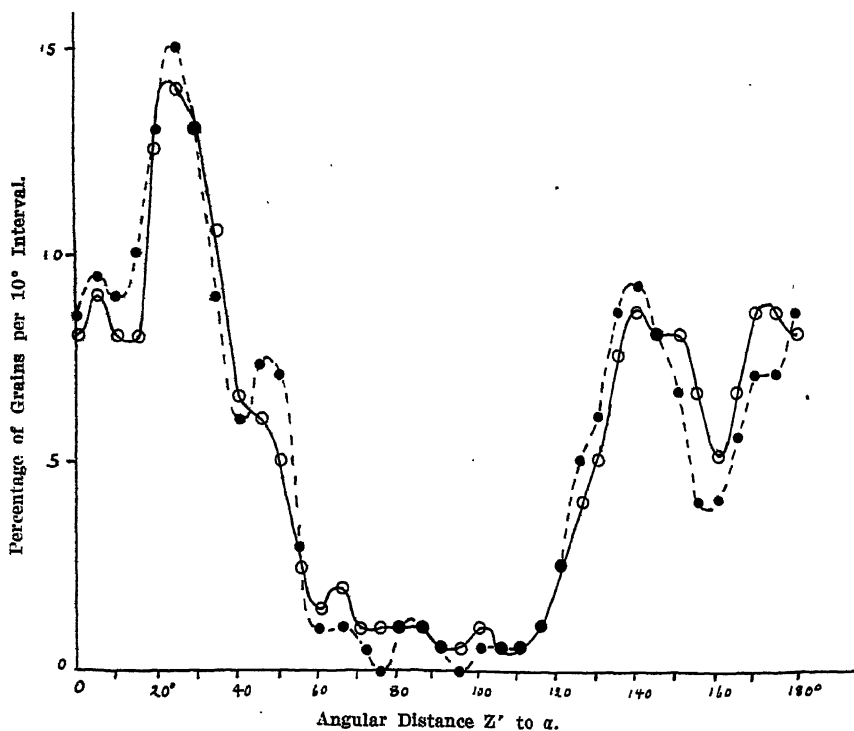


FIG. 6.—Orientation curves for quartz in *ac* section of specimen No. 4525; broken curve represents 450 grains in a single rock section; full curve represents 900 grains in two different sections, including that upon which the broken curve is based,

Sections perpendicular to each of the three fabric axes were cut (Fig. 3B) and the quartz fabric was analysed following the method described by the writer in previous papers (Turner, 1936, 1938). This involves measurement of the angle Z' to b (or a) for a large number of quartz grains in each section, using an ordinary petrographic microscope fitted with a simple mechanical stage. The results are graphically represented in Figs. 4 to 6. The main features of the fabric are clearly indicated and are summarised below:—

- (1) A pronounced minimum parallel to b (Figs. 4 and 5).
- (2) Strong concentration of the quartz axes (Z) in the ac plane (Figs. 4 and 5).
- (3) A second minimum parallel to c (Fig. 6). This is borne out by the prominence and sharpness of the maximum in the ab curve (Fig. 4) compared with the less pronounced and broader zone of concentration perpendicular to b in the bc curve (Fig. 5). Prevalence of grains showing low double refraction in the bc section also indicates that the majority of the grains are oriented with their optic axes not greatly inclined to a .
- (4) Presence of three maxima in the ac concentration zone, situated respectively at angular distances of 25° and 145° from a and parallel to a itself. To test the validity of these maxima a second ac section was cut and the component quartz grains measured. The two sets of results showed a very close correspondence as will be seen in Fig. 6 by comparing the broken curve (representing a single section) with the full curve (combining the results obtained from the two sections).

Figs. 7a and 7b show the positions of the deduced maxima in stereographic projections upon ab and ac respectively. In Fig. 7c a contoured orientation diagram, such as might correspond to the orientation curves of Figs. 4 to 6, has been constructed in stereographic projection. The positions of contours are not represented accurately, but their general pattern has been deduced broadly from consideration of the orientation curves. Thus the points where the a axis is cut by contours corresponding to the percentages 2, 4, 6, 8, 10 and 12 the ac curve of Fig. 5 were constructed stereographically in the contoured diagram. Some degree of elongation of one or both of the principal maxima toward the negative end of the b axis is indicated by the form of the bc curve, and is shown accordingly in Fig. 7c. The reconstructed figure though obviously far from exact does indicate the main features of tectonic significance, viz. the positions of the main maxima and minima, the broken ac girdle, and the general pattern of the quartz orientation. Further it allows rapid comparison with the standard contoured diagrams constructed from results obtained with a universal stage.

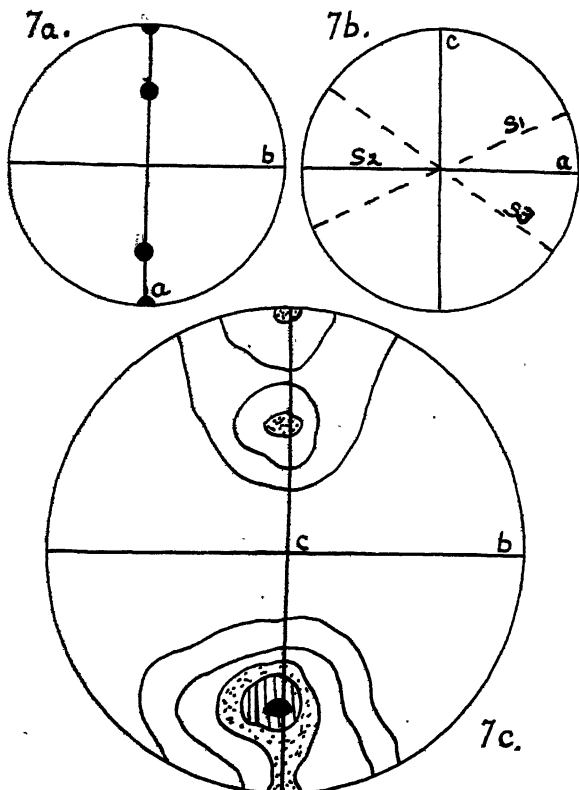


FIG. 7.—(a) Stereographic projection upon ab showing the points of maximum concentration of quartz axes (Z) in Pomona Island granite, No. 4525.
 (b) Stereographic projection upon ac showing relative positions of S_1 , S_2 and S_3 in specimen No. 4525.
 (c) Stereographic projection upon ab with hypothetical contours indicating the type of orientation that could account for the data recorded on the orientation curves in Figs. 4, 5 and 6 (quartz in specimen No. 4525).

In the previous section it was shown that the lineation in the granites of the southern marginal zone was developed by flow of the partially crystallised magma parallel to the lineation itself. The quartz fabric just described however, is not obviously related to such a movement and must have originated during continued deformation after cessation of magmatic flow. The universal undulose extinction exhibited by the grains, now generally interpreted as a result of gliding in crystalline grains on $(10\bar{1}0)$ in a direction parallel to the vertical crystallographic axis (Fairbairn, 1937, p. 38), is itself an indication that the present orientation of the grains is due to "plastic" deformation of the solid rock and not to "viscous" deformation of a partly crystalline magma. From the orientation diagrams it follows that the direction of gliding was perpendicular to the lineation. On one interpretation it may have occurred in two principal planes (S_1 and S_3 of Fig. 7b) inclined respectively at 25° and 145° to the foliation (S_2), and

probably also to some extent in the plane of foliation itself. Sub-horizontal compression acting more or less perpendicularly to the foliation in the closing phases of orogeny could give rise to such a movement in S_1 and S_3 and need not have involved much actual transport (cf. Sander, 1934, p. 42). On the other hand, following Schmidt's interpretation of the significance of maxima in B-tectonite girdles, the orientation diagrams just described may indicate operation of a compressive force acting parallel to the a fabric axis (cf. Schmidt, 1932, fig. 49; Phillips, 1937, p. 598). In either case there is an intimate relation between the linear and foliated structures produced by magmatic flow, and the quartz fabric resulting from later deformation of the solid rock, though the actual directions of the movements concerned in the earlier and the later phases are mutually perpendicular. Fairbairn (1937, pp. 112, 113) summarises other instances where the fabrics of foliated intrusive rocks show that the latest movements occurred across the flow-lines after solidification, thus giving rise to a B-tectonic girdle perpendicular to the principal lineation.

In conclusion, attention may be drawn to the similarity between the reconstructed contoured diagram representing the quartz fabric of the Manapouri granite, and the orientation diagrams for quartz in certain foliated pegmatites discussed by Sander (1930, pp. 184, 185; D.30, 31, 33, pp. 307, 308).

ACKNOWLEDGEMENTS.

The writer gratefully acknowledges the financial assistance of the Australian and New Zealand Association for the Advancement of Science in defraying the cost of field work. He is also indebted to Dr. L. H. Briggs for assistance in field work and to the Murrell brothers and Miss Murrell, of Manapouri, for their hospitality. His thanks are also extended to Professor W. N. Benson for helpful advice during laboratory investigations.

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CORRIGENDA TRANS. ROY. SOC. N.Z., Vol. 67, 1937.

Page 341, par. 1, line 10, insert " ranging " between
" stages " and " from."

do., par. 2, line 4, insert " a few " between
" contained " and " loose."

do., par. 3, line 13, read " could " instead of
would.

Page 342, line 2, insert " of a ripe specimen " between
" mesovarium " and " could."

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AND
PROCEEDINGS
OF THE
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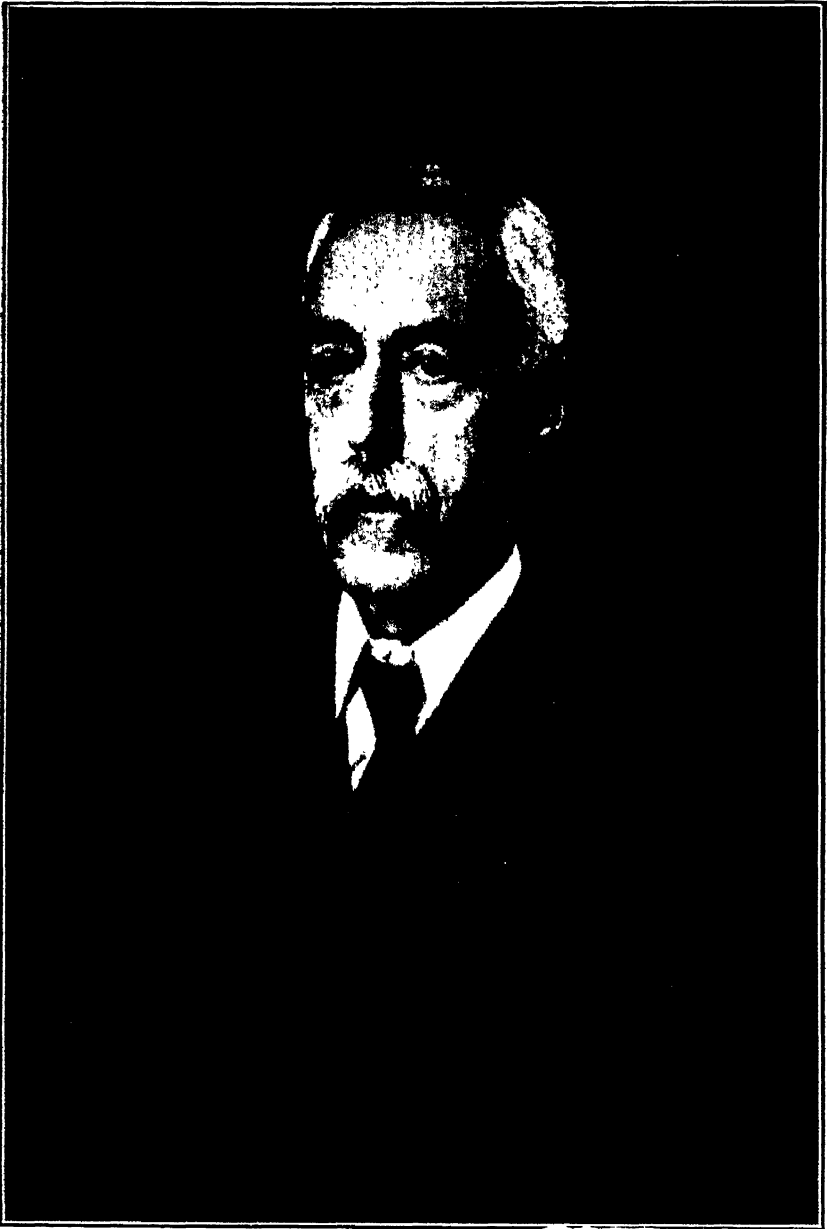
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the Editor of the "Entomologist."

The late Edward Meyrick.

Edward Meyrick, B.A., F.R.S., 1854–1938.

EDWARD MEYRICK, one of the most renowned workers on the microlepidoptera of the world, died at his residence, Thornhanger, Marlborough, England, on the 31st March, 1938. He was the son of the Rev. Edward Meyrick and was born at Ramsbury, Wiltshire, on November 24th, 1854. He was educated at Marlborough College and Trinity College, Cambridge, and was for 37 years a schoolmaster. He went to Australia in December, 1877, taking up a position in Sydney Grammar School in 1878. During 1882-83 he taught at Christchurch Cathedral Grammar School, New Zealand, but returned to Australia to teach at the King's School, Parramatta, N.S.W., till the end of 1886, when he left for England and became assistant master at his old school, Marlborough College, a post he held until his retirement in 1914.

It was in January, 1886, on his return from an entomological trip to the Tableland of Mount Arthur, that the writer of this notice first had the pleasure of meeting Mr. Meyrick. Rather spare and tall in figure, upright, and extremely alert, his personality was most impressive and his manner inspiring. His keen enthusiasm was irresistible. Although searchingly critical, his criticisms never discouraged those he criticised, but induced them to make greater efforts to attain scientific accuracy. His concluding remarks, when commenting on a crude essay on entomological classification written by a young and inexperienced author, may be quoted as characteristic: "You have only made the common error of theorising from insufficient facts and the remedy is to study more facts. Please do not take offence at my plain speaking, which is intended for the benefit of yourself and of science."

Mr. Meyrick's first contribution to our *Transactions* was read before the Philosophical Institute of Canterbury on the 4th May, 1882, and appears on page 3 of volume XV. From that time, until his last paper in 1937, a period of 55 years, he regularly contributed articles on New Zealand Lepidoptera, his work in this respect alone probably constituting a record. But it must be borne in mind, in reviewing the activities of so great a worker, that his publications relating to the New Zealand fauna constitute only a very small fraction of his life work, and it is quite beyond the scope of the present notice to give anything more than the briefest possible sketch of his general entomological work. It is estimated that during sixty years of active work at least 20,000 new species were described by Meyrick, as well as many new genera and several new families of Lepidoptera. His output was prodigious. He wrote many papers on the Lepidoptera of Australia, New Zealand (besides those in our *Transactions*), the South Pacific Islands, Burma and Malaya, India, South Africa and South America, besides his contributions to such works as Wytman's *Genera Insectorum* and Junk's *Lepidopterorum Catalogus*. He made a notable contribution to the knowledge of the Lepidoptera of his native land in *A Handbook of British Lepidoptera*, published in 1895, of which he issued a revised edition in 1928, now in general use. As the publication of so many descriptions, published in various parts of the world, proved inconvenient, Mr. Meyrick started in March, 1912, his *Exotic Microlepidoptera*, humorously described in the preface as "a spasmodic entomological magazine on one subject by a single contributor. Of this he issued four complete

volumes and part of volume five, making a total of some 2,500 pages. With the issue of *Exotic Microlepidoptera* his separate papers were mostly discontinued, except additions, etc., to the New Zealand Lepidoptera which continued to appear in our *Transactions*, and a series of papers in the *Transactions of the Entomological Society of London* on South American species.

Mr. Meyrick was elected an Honorary member of the New Zealand Institute in 1907. He became a Fellow of the Entomological Society of London as early as 1880, being the second senior Fellow when he died. He joined the Zoological Society of London in 1889, and was elected a Fellow of the Royal Society in 1904. He was awarded the Captain Scott Memorial Medal of South Africa in 1927. He was president of the Marlborough College Natural History Society until 1914, and played a great part in encouraging the study of natural history in the school.

Edward Meyrick was actively at work until a few days before his death. He made a regular daily practice of working until an hour after midnight. His collection contained such a large proportion of the known Microlepidoptera of the world that he rarely needed to visit the British Museum (Natural History); the collection, of inestimable value, was bequeathed to that institution, where it is now safely housed.

In dealing with his brother naturalists, Mr. Meyrick followed the highest ethical principles. As examples of this it may be mentioned that he always gave the fullest credit to other workers; all questions referred to him were invariably answered with the greatest possible promptitude, and he exercised the greatest care in returning entomological postal boxes to their owners immediately after the contents had been disposed of. He was a staunch Darwinian, as indicated in the following advice given in 1889: "For a general guide to the principles of classification, biologically, read Darwin, who is, and probably will long remain, unequalled for a combination of special knowledge and general theory; and for an example of classification most ably carried out, his monograph of Cirripedes." It can, I think, be safely said that subsequent developments have in no way detracted from the value of this advice.

Whilst agreeing that "associations, congresses, codes of rules to be enforced, and the like, are very well in the conduct of affairs of every day life, where the prevalence of the will of the strong majority affords a practicable base for agreement, they are altogether mischievous in science, which is concerned with eternal truths and principles, which cannot be altered or suppressed by a majority of votes. Every scientific worker of independent mind should therefore continue to maintain his own views, confident that if they are true, the majority will one day be on his side, whatever they may be now."

It is manifest to one who has had the privilege of a life-long association that Meyrick was no cynic, or pessimist, but was confident of the ultimate triumph of right. This can be inferred from a remark he once made about a proposal for human betterment, whose real authorship was not recognised as it should have been. In directing attention to this Meyrick said: "Rest assured that it is more blessed to have done well than to have the credit of it." Thus in every way Meyrick was a worthy follower of the great nineteenth century scientists who immediately preceded him.

G. V. H.

4

5

Morainic Deposits of the Waimakariri Valley.

By R. SPEIGHT.

[*Read before the Canterbury Branch, December 1, 1937; received by the Editor, February 22, 1938; issued separately, September, 1938.*]

Introductory Summary.

THE occurrence of moraine in the valleys of the New Zealand rivers presents certain anomalies, so that it may be appropriate to consider in particular the case of one typical river, viz., the Waimakariri.

The dominant physical features of the upper basin of this river have an important bearing on the distribution of moraine, and therefore it may help in the presentation of the subject to give a brief account of the mode of origin and nature of this basin before the onset of the ice-flood. In a general sense it has been formed by the deformation through down-warping and faulting of an area of the late Tertiary Southern Alps peneplain and its covering beds. The foundered portion is bounded on the west by the Craigieburn Mountains (altitude about 6000 ft.), and is connected in that direction with the Trelissick or Castle Hill basin, already described by the present author (Speight, 1917, and 1935). On the south the intermont is bounded by the Torlesse Range (6553 ft.), along the northern base of which flows the Broken River with a general E.-W. orientation. On the east the boundary is formed by the high continuous ridge of the Puketeraki Mountains (6347 ft.), along the flanks of which runs the main Waimakariri River in a deep, continuous, rocky gorge. It should be noted that the river does not lie in this part of its course on the actual floor of the basin, but has excavated its bed on the slopes leading down thereto, so that there is a well-defined greywacke ridge rising to a height of 3380 ft. in Mount Rosa, between the river and the floor of the basin to the west. On the north side the boundary follows generally the line of the bed of the Waimakariri between the mouth of the Cass and Mount White, with a possible subsidiary basin extending upstream from Cass past Bealey to the Crow River. On this northern boundary spurs from the main divide run down finger-wise to the main stream and separate valleys occupied by the following tributaries:—the Crow, Bealey, Hawdon and Poulter, while further east the Esk River drains a tract of country between the Puketeraki Range and the spurs running east and south from the Candlestick Mountains (6628 ft.), but not reaching the main divide.

The formation of this intermont was the result of diastrophic movements under whose influence a number of structural and landscape elements were developed (1) with N.E.-S.W. orientation, and (2) with N.W.-S.S.E. orientation. To the former may be assigned the valley of the Esk, which occupies a fault angle depression, while to the latter belong the ridges stretching from near Cass towards Broken River, which determine the Grasmere-Pearson-Winding Creek valley and that occupied by Slovens Creek right from St. Bernards

Saddle to Broken River. In addition to these, and not obviously structural, are a number of subordinate valleys lying to the east of Slovens Creek which drain either to the Puketeraki section of the Waimakariri River or to Broken River, the chief of which rises near Trig I, while smaller ones still run from Lake Blackwater—when it overflows—and past the old Avoca homestead. A special feature of these streams so oriented is that however open their upper and middle courses may be they discharge to Broken River or to the Waimakariri by deep, rock-bound gorges.

In this part of the intermont the floor lies at an elevation of about 2000 ft. and shows a somewhat uneven surface, though the irregularities have been smoothed by ice action so that flowing contours are characteristic, ridges are frequently cut into sections, and detached hills are common. Some of these last must have always maintained their summits above the ice-level in the form of nunataks (e.g. Mount St. Bernard), but most of them must have been completely submerged when the ice was at a maximum, for scoured surfaces extend at times right over their summits. The south bank of the Waimakariri below the Cass is marked by isolated remnants of such a ridge—e.g. the elevations known as the Sugarloaf, Gog, Magog, and that marked Trig. I are the results of such a dissection, and through the gaps between them the ice crowded at one stage to deploy on the flat, open floor of the upper part of the Slovens Creek area.

North of the broken barrier just referred to stretches for some 25 miles a trench, now occupied by the main stream, whose base is depressed below the general level of the floor of the intermont by between 300 and 400 feet. This hollow is veneered almost completely with gravels brought down by the main stream and its tributaries whose lower reaches are masked in the same way, and enter the main stream at grade. The lower part of this trough is structural in origin, for just above the junction with the Esk, Tertiary limestones show through the gravel floor. It has, however, been modified by glacial erosion, for here the ice reached a great thickness, the trough acting as a great collecting and distributing area, and the ice persisting in mass long after the floor of the intermont to the south had been completely evacuated. When the ice retreated up the main valley and the lower part of the Poulter valley from the junction of the Esk, their floors were occupied by a lake in which varved silts were deposited, and as this condition demands that a barrier existed on the downstream side, it is reasonable to assume that the great Puketeraki gorge of the river was only partly cut at that stage and that a barrier still remained behind which an extensive lake could be ponded.

This brief summary has been given so that the situation of the morainic deposits may be more fully appreciated, for it will be seen that they occur in general where some accident in topography has facilitated deposition and the preservation of what has been deposited. An important point to be noted is the relative absence of morainic deposits in parts of these valleys where the other physiographic evidence of the former presence of glaciers is conclusive.

Long stretches show no moraine at all, whether terminal, lateral, or stadial, and this suggests that some peculiar condition determines at times the continued existence of moraine. When dealing with special cases of deposition consideration will be given to this aspect of the problem. These will now be taken in turn from the eastern to the western side of the intermont.

Lochinvar. (Photos 1, 2.)

The most extensive morainic deposit in the valley of the Waimakariri is that which lies west and north-west of the old Lochinvar station, now an out-station of Mount White. This occupies part of the Lochinvar Plain, a flat area bounded on the north by the outskirts of the Candlestick Mountains, and on the south by the mountain mass of which Mount White and Mount Peveril are the dominant peaks. The area is probably structural in origin, being a strip of country which has been faulted down, but it has been modified by the flood of ice which once occupied the region. In pre-glacial, and perhaps during early glacial times, the Cox River, formerly known as Cox's Poulter, now a tributary of the main Poulter, discharged south-east to the Esk River by way of the Lochinvar Plain and the lower course of Nigger Creek, but at one stage in the glacial history a great moraine was piled across the western end of the Lochinvar Plain and the Cox was diverted south-west through a rough, rocky gorge to the main Poulter. The area covered by moraine is remarkable, and it impressed Haast in the early days (1879, p. 151). Extending over several square miles of flat are large irregular dumps deposited by the Cox Glacier with lakelets lying in the hollows (Photo 1), and fronting this in tongue-like form is an area in which the hummocks are much smaller (Photo 2). This last must have been deposited in a comparatively short space of time, whereas that required for the deposition of the great dumps must have been somewhat lengthy. It should be noted that Nigger Creek which now drains this area, after flowing for a considerable distance in an open, ill-defined, and swampy channel—perhaps the floor of an old, shallow lake—passes through a deeply incised gorge to reach the Esk River. The landscape forms in its vicinity prove that the ice reached a long distance past the Lochinvar moraine at one stage, and the moraine itself marks a halt in a retreat from this advanced position, or a readvance from a line much further back and nearer the main divide.

Junction of the Poulter and Waimakariri. (Photos 3, 4.)

An extensive area of moraine is located in the angle between the Poulter and Waimakariri Rivers at the base of Mount Binser. This owes its presence partly to the Waimakariri and partly to the Poulter Glacier, material having been dumped from the sides of both on a kind of no-man's-land lying between them as they issued each from its own valley, and being preserved after deposition, since it was not exposed in its somewhat sheltered position to the erosive action of ice or of the rivers issuing from the front of each glacier whether combined or not.

There is also a thin veneer of moraine distributed discontinuously on the country near the Mount White station and on in the direction of the junction of the Esk with the Waimakariri, but this was exposed to the action of the streams issuing from the front of the Poulter Glacier and so the deposit is of no great magnitude.

Another extensive area of deposit is that on the south bank of the Waimakariri opposite its junctions with the Poulter and Esk, around Lake Blackwater, and on the northern base of Mount Rosa, with an extension south-west of the lake through a trough leading towards the head of Puffers Creek, a tributary of Slovens Creek. Half a mile south-west of the lake this trough is crossed by a stream which rises between Trig. I and the Craigieburn homestead, runs first of all in a narrow, deeply incised channel for a mile and a half, then in an open bed flanked by moraine and river terraces (Photo 3) past the northern end of the Mount Rosa ridge to enter the Puketeraki reach of the main river by a deep, wooded gorge. Other crescentic morainic ridges, evidently deposited by a glacier coming from the north-east, cross this trough, and dumps occur on the shoulders of spurs facing the same direction, while scattered blocks lie on the slopes above. The lake, which is little more than a large pond, lies among morainic heaps (Photo 4) and north of it these deposits cover an area of some three square miles. They lie at two definite levels, the upper with large and irregular mounds, the lower with smaller and more subdued heaps of debris. The material has come from both the main glacier and that of the Poulter valley, the latter in all probability contributing most, for its valley is almost equal to the former in size, and its glacier had not been diminished to any great extent by distributaries, the only one of importance coming down Andrews Creek. The preservation of these moraines can be attributed to their having been deposited in a locality not exposed to the action of powerful streams issuing from an ice-front. It may be mentioned that the trough just referred to is perhaps structural in origin, for it lies in a direct line with the fault-angle valley of the Esk and only a short distance from where the Tertiary limestone has been faulted down into the bed of the main stream. If this line be followed south-west it will coincide after very slight variation in direction with that of the fault which bounds the Tertiary beds on the lower part of Slovens Creek on their eastern side.

Lake Sarah-St. Bernard Saddle Area.

A very interesting area of deposit occurs near Lake Sarah, south of the Sugarloaf, continuing on to the St. Bernard Saddle and the slopes of Gog. Near the lake itself to the north-east of the railway the deposit is entirely moraine showing characteristic hummocky topography. Some of this has been deposited by a glacier which came from the north-west and the direction of the lake and other has been deposited by the main glacier which has come round the southern face of the Sugarloaf and dropped its load in this somewhat sheltered locality. An outflow channel from the glacier front drains towards the lake indicating that the Waimakariri Glacier invaded territory which hardly belonged to it, so this moraine is to be credited to two ice fronts. Then there are

the fluvio-glacial moraines which lie on the south-western side of the railway, covering the St. Bernard Saddle, and extending east on to the northern slopes of Gog. These have been described by Gudex (1909, p. 33). They can almost certainly be attributed chiefly to a distributary of the main Waimakariri Glacier, which crowded through the gap between the Sugarloaf and Gog.

Slovens Creek Area. (Photo 5.)

Patches of moraine occur in the upper part of the basin of this stream on the slopes of Gog; on the northern slopes of St. Bernard; in the gap between Magog and Trig. I, near the Craigieburn homestead; and on the rising ground to the east in the direction of Mount Rosa. However, the most striking feature of this area is the flood-plain of a river which once issued from the front of a distributary of the main glacier when it reached about a mile below the present Craigieburn homestead. This has an accordant surface stretching across the middle portion of Slovens Creek from Puffers Creek on the east right to the neighbourhood of Vagabonds Inn on the west. The bed of Slovens Creek has been incised in this flood-plain to a depth of some 300 ft. (Photo 5).

The basal beds of the area are greywacke with some overlying coal measures, and in the upstream direction they present a steep face directed north, and crossing the bed of the creek. Behind this barrier a shallow lake was ponded at one time, remnants of which are the small lake Marymere to the west of the railway, and the swampy ground to the east which contains near the railway station a somewhat extensive deposit of diatomaceous earth. The former lake was emptied as Slovens Creek lowered its bed subsequent to the glaciation.

On the surface of the barrier lies a veneer of moraine which extends on the eastern side of the stream over a considerable area where it merges into outwash plain. At first sight this appears flat and regular, and so it is in its distal portion, but in the upstream direction the regularity is broken to some extent by roughly crescentic low morainic dumps, of which three—perhaps four—lines are preserved, separated by small outwash plains in which are remnants of dumps. No doubt moraine once extended as far as the junction of Puffers Creek with Slovens Creek, near which definite moraine is exposed, but it has been subjected to the wash of glacial streams forming the plain, so that the dumps have been scattered, buried, or removed in the downstream area, and all that is left to indicate their former presence is a very occasional large block that the streams were incompetent to remove entirely or to bury. This is an excellent example of the ability of a powerful stream issuing from an ice-front on to an outwash plain to remove all surface evidence of moraine from its vicinity.

As mentioned previously this flood-plain extends across Slovens Creek towards the eastern slopes of Mount St. Bernard, but west of Vagabonds Inn (2052 ft.)—an old camping ground for trampers—moraine extends in the same direction, and south of it lies an outwash plain at a slightly higher level than that of Slovens Creek.

Near the Inn itself are hummocks mantled with moraine, and in my opinion they are not formed entirely of transported material, but this is merely a veneer over rock in situ, either of greywacke or of the Cretaceous coal measures exposed in places on the northern slopes of Noman's Land.

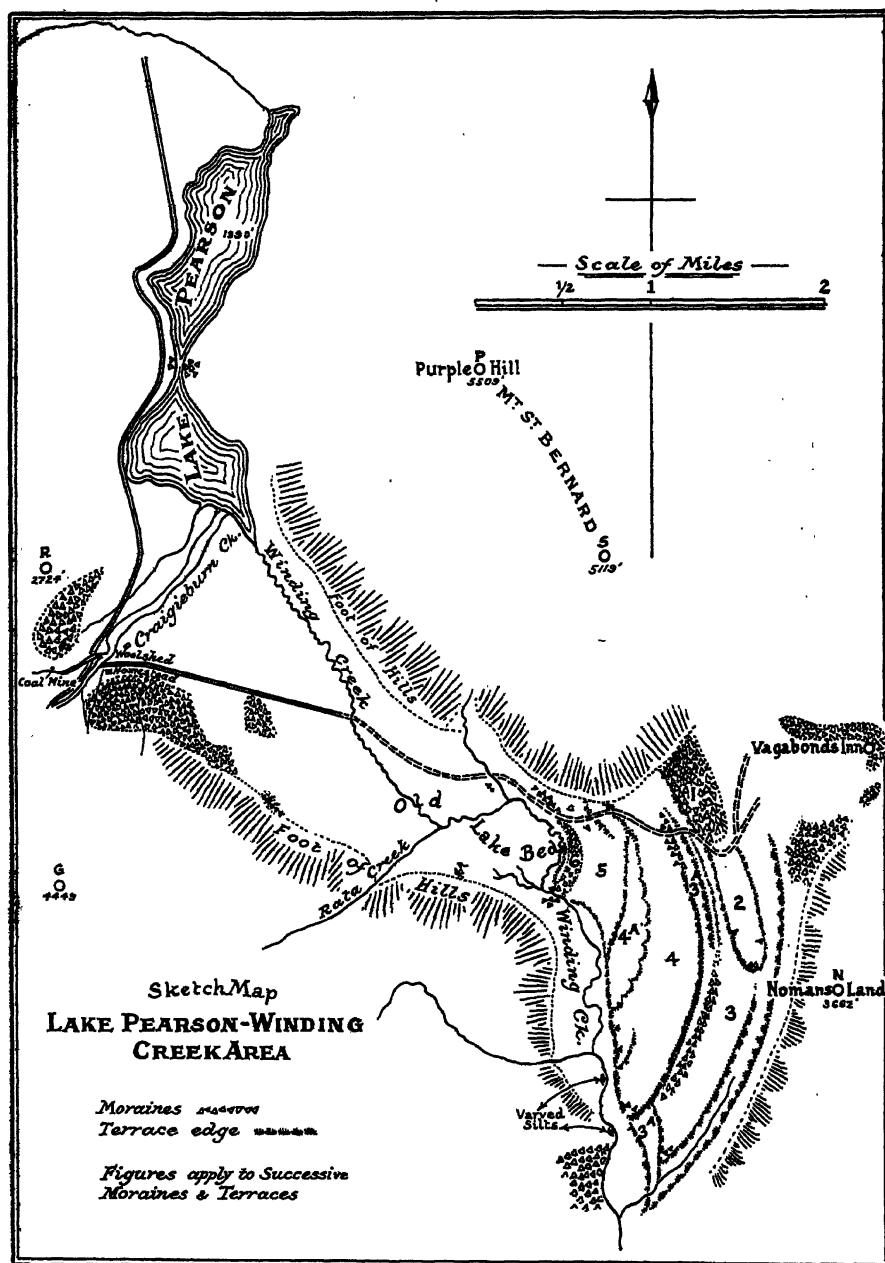
To the east of the Slovens Creek outwash plain moraine occurs on the hillsides, especially where it has been sheltered from erosion in nooks and corners and above the wash of streams. In addition numerous perched blocks lie on the smoothed western slopes of Mount Rosa and of the range of hills extending south from the Craigieburn homestead. The furthest downstream that moraine occurs in the Slovens Creek area is at its junction with Puffers Creek, and it also occurs in the elevated U-shaped trough running south-east from the old Avoca homestead. It forms a fringe to the north-west lip of the trough, and occurs on both sides of the valley leading therefrom towards the reach of Broken River below the bridge. About a mile from the site of the house lies a terminal moraine, with a double row of crescentic hummocks, breached by the stream which issued from the glacier as it was retreating through the trough. A large, high *roche moutonnée* rising from its floor must have divided the ice-stream into two parts at an advance and at a retreat stage in its history.

Lake Pearson-Winding Creek Area. (Sketch-Map No. 2 and Photos 6, 7.)

An interesting and extensive area covered with moraine lies between the northern end of Noman's Land—an elevated tract of country (3662 ft.) forming a tilted block and lying between the lower courses of Slovens and Winding Creeks—and the southern end of the St. Bernard Range. The deposit is largely due to the dumping of material from the sides of glaciers flowing past the east and west flanks of the range on to ground not directly exposed to erosion by them or to that of the streams issuing from them. As conditions changed, the country to the west was directly subjected to the action of the glaciers which came from the north over the site of Lake Pearson.

The uppermost terrace (marked 1 on the map), which stretches south from the end of the St. Bernard Range, consists of large angular blocks unmodified by stream action, and the same applies to the irregular dumps which mask the lower slopes of the northern end of Noman's Land and lie in all probability on faulted down Cretaceous coal measures as well as on greywacke. These two morainic areas have been separated by a stream which issued from the front of the glacier flanking St. Bernard on the east and discharged to Winding Creek instead of to Slovens Creek as might be expected. The upper end of the channel is now dry, but the lower end has been incised in terrace (3) subsequent to the latter's formation by the drainage it has collected from the adjacent slopes of Noman's Land.

Terrace (2) is oriented in the same direction as (1), the edges of both being in alignment and it too in all probability has been



No. 2.

formed by a stream common to the glaciers east and west of St. Bernard. Although formed by water, large blocks show occasionally on its surface, its flanks and on its distal end.

After a number of small intermediate terrace remnants extending towards the slopes of St. Bernard in a northerly direction on the flanks of (1) and (2), the next important terrace (3) forms a wide outwash plain half a mile in width where broadest, and extending nearly two miles downstream towards the rocky gorge of Winding Creek. Its north-western margin is marked by a row of morainic dumps, sometimes a double row, which becomes indefinite towards the northern end and merges into one of the intermediate terraces just mentioned, but becomes very definite downstream and extends to the west across the gorge of the river on to the slopes of Broken Hill. In places the moraine lies several chains back from the edge of the terrace. The surface of this outwash plain is beautifully accordant and must be attributed to the stream which issued from the glacier front as it reached the moraine just mentioned. Only towards the lower end do large blocks appear, though others no doubt occur buried beneath the accordant surface. Subsidiary terraces (3a) lie along its western front, and towards the northern end one of these is marked by a well defined lateral moraine.

Terrace (4), and also its flanking terrace (4a), at a lower level, give little evidence of the proximity of ice, though they must both have been determined upstream by a former ice-front. The only signs of its proximity are occasional morainic blocks at the proximal end against the slopes of St. Bernard, in scallops on the northern face and along the termination of both on the high banks of Winding Creek. The upper surfaces of both (4) and (4a) are reasonably flat and grade evenly downstream.

At their base lies a flat outwash plain (5) with occasional blocks at its northern end, and bordering it to the north and north-west is a typically developed terminal moraine (6) extending in crescentic form, with convexity directed downstream, from the slopes of St. Bernard right across the bed of Winding Creek towards the slopes of Broken Hill (Photo 6), except where it has been breached by the stream. Low and indefinite terraces, perhaps lake beaches, but more probably of stream formation, lie on the northern side of this moraine. The outwash plain (5) was no doubt formed when the glacier reached this moraine.

The total height involved from (1) to (6) is estimated at approximately 600 feet.

It should be noted as well that two small exposures of varved silts occur between this moraine and the upper end of the gorge, the lower one with well-developed alternations of clay and sand, and the other more sandy, while under moraine (6) on the bank of the stream there are indefinite sandy layers perhaps due to the same cause and laid down close to the ice front. The two undoubted instances are covered first of all by terrace gravels and in one case certainly by moraine as well. They show that at one stage, antedating the deposition of moraine, a lake existed in this area ponded

back on the downstream side by the yet uncut barrier where the gorge is now situated. It is remarkable how the lower courses of Winding Creek, Slovens Creek, and even the main Waimakariri, have all been incised after the retreat of the ice.

This area appears to me the most interesting in its bearing on the glacial problem in New Zealand that it has been my fortune to come across, and it well merits detailed investigation. The following is my interpretation of the sequence of events after several examinations, and it is put forward with all due diffidence, and with the certainty that some day it will be thoroughly revised.

The main glaciation of the area is indicated clearly enough by the general landscape features such as the scoured surfaces of Noman's Land, and the facettted spurs of St. Bernard, Broken Hill, etc., but the special interest is connected with the events following on the deposition of the high-level moraines between St. Bernard and Noman's Land. These appear to me to be as follows:—

1. Glaciers advance or hold their own after a general retreat, eroding a basin in a fault-formed valley, previously modified to some extent by the main glaciation. Note that the valley of Winding Creek has been determined by a fault or faults, the evidence for which is remnants of coal measures which in places occur on the floor of its gorge.
2. Retreat of the ice leaving a hollow with a barrier on the downstream side, not yet incised by the stream, and behind which a lake was ponded in which varved silts were laid down.
3. Advance of streams over this deposit covering it with gravel, the stones being well rounded and the ice-front evidently some distance back.
4. Advance of the ice, formation of the outwash plain (3) and the deposition of moraine along its edge, these deposits being laid down on the lake silts, which were not completely removed by ice or stream erosion.
5. Retreat of the ice, and the deposition of terraces (4) and (4a) with little sign of the presence of ice in the vicinity. It retreated in all probability further upstream than the present position of moraine (6). At this stage the incised gorge of Winding Creek was probably cut, a temporary lake—not the same as that in which the varved silts were laid down—occupying the floor of the valley.
6. Readvance of the ice forming the lowest level moraine (6) and its outwash plain (5). A lake, now occupied by the swampy meander belt of Winding Creek was ponded back by this moraine which was drained when the moraine was breached, and the terraces on its upstream side were then formed.
7. From this onward in time there was the deposition of stadal moraines across the floor of the valley as the ice retreated towards Cass. Reference to these will be made now.

The first of these moraines is indicated by a small hummock on the western side of the mouth of the stream issuing from St. Bernard, and by two larger hummocks lying against the western side of the valley directly opposite, below the tributary called Rata Creek. The second occurs near the Flock Hill homestead, first as a detached collection of hummocks (see map) about a mile from the homestead, and then as an extensive area on both sides of Craigieburn Creek at the outlet from its gorge. Although this occurrence has the hummocky surface characteristic of moraine there is a notable paucity of angular blocks, and such as occur appear to lie on fluvio-glacial material and boulder clay (tillite) with a few scratched stones. In this case at one stage the ice climbed the greywacke barrier in the direction of Castle Hill and the deposition of tillite is a common occurrence on the upstream side of such a barrier. This deposit may date from an early stage of the glaciation, and the blocks that do occur on the surface may be a somewhat late addition. It is best developed on the south side of the Craigieburn between the homestead and the lower slopes of Broken Hill, and also on the opposite side of the stream immediately north of the coal mine, where large blocks occur more frequently.

The next of these almost divides Lake Pearson into two subequal areas, but it has been almost obscured by two shingle fans which come in from opposite sides of the lake at this point. It might be urged that the fans are entirely responsible for the constriction of the lake, but the size of some of the blocks much exceeds those usually brought down by streams forming fans.

The next moraine lies between Lakes Pearson and Grasmere, and has been responsible for the change in the direction of drainage of the area occupied by the latter lake. This now runs to the Cass, a reversal of its former direction. The moraine abuts on the east right against the rocky ridge running in a northerly direction from Mount St. Bernard (Photo 7), while the western end is overwhelmed by the fan of Ribbonwood Creek which issues from the Craigieburn Mountains on the west. Nevertheless a considerable area of the moraine is clearly exposed, showing hummocky ridges arranged in crescentic pattern and the convexity directed towards Lake Pearson.

The last area lies to the west of Lake Grasmere right against the Craigieburn Mountains, and this merges into lateral moraine in the direction of the outlet of the gorge of the Cass River, and it may link up under fan material in the other direction with the moraine between Lakes Grasmere and Pearson.

These moraines were no doubt formed during halting stages in the last retreat of the ice. The distributary of the main Waimakariri Glacier responsible for them crossed the Mount Misery-Goldney Saddle ridge near Cass and the ice-stream was of relatively small importance. The grade of the valley was also low, and in fact at its northerly end the grade was reversed. Also, it was formerly even more completely occupied by lake than at present. The moraines, therefore, owe their preservation in such perfect form to not having been exposed to the full force of a powerful stream issuing from the main front of a large valley glacier, and especially so since the grade of the valley was comparatively flat.

Other Moraines.

In addition to these deposits, moraines of small size are found near the heads of some of the main valleys, for example, the Upper Bealey, the Hawdon, and the basins at the head of the Craigieburn and Broken River, but they are absent in other cases where they might be expected. It should be noted too that deposits which look like moraine are in some cases due to rock falls consequent on earthquake or without that agency. An excellent example occurs in Thompsons Creek, a tributary of the Poulter, and the barrier behind which Lake Minchin is ponded at the head of this river is probably attributable to such a fall. Even if such deposits are glacial, it is remarkable what great lengths of the valleys contain no deposit even simulating moraine.

Mention might be made here of the presence of moraine in the valley of the Kowai, a tributary of the Waimakariri entirely outside the intermont, and rising on the south-eastern slopes of the Torlesse Range. First of all, moraine occurs at the head of Macfarlanes Creek, a tributary of the Kowai rising just south of Porters Pass, but this is more probably attributable to an offshoot of the Rakaia Glacier, which entered the basin of the Kowai over a somewhat low saddle. There are also two occurrences in the main Kowai, lying at the mouths of tributary streams coming directly from the Torlesse Range, one of which is certainly moraine, and the other probably so. They are additional to deposits which might be attributable to rock falls associated with a recent earthquake rent passing through Porters Pass and which are almost certainly not glacial; these lie nearer the pass.

Absence of Moraine.

The only trace of the former presence of ice in many localities is that furnished by the form of the landscape as cut from the solid. What then has become of the moraines or have they ever existed in these places? It should be noted that many of our present-day glaciers have no terminal moraine. Those at the end of the Tasman Glacier are small when the amount of debris on the surface of the glacier is considered. The Lyell Glacier at the head of the Rakaia has little or no terminal moraine, and the same is true of the Franz Josef and Fox Glaciers on the West Coast. In all these cases the rivers issuing from the glaciers are competent to carry the moraine away as fast as it is delivered at the ice-front, and the same conditions may have obtained in bygone times. There is no such thing in the case of a retreating glacier as an annual moraine such as can be seen in Sweden, whose precise date can be assigned in the Swedish time scale. Stadial moraines, such as have been mapped in various glaciated regions occur in the Waimakariri basin only in the Cass-Pearson-Winding Creek valley, and even these are not precisely regular or typical.

Their absence may perhaps be explained on the Flint hypothesis (1929, pp. 256-89) that glaciers disappear from long stretches of the valley during retreat by wastage from the sides, and especially is this likely if for any reason tributary glaciers fail as well, owing to the decline of the névé fields at their heads, to maintain connection

with the trunk glacier. Such might well occur in the case of the Waimakariri trough, if the tributary glaciers from the Hawdon, Poulter, Bealey, and other valleys failed at their heads. The moraine covering the trunk glacier would then be deposited as a mere veneer on the valley floor and would soon be dispersed or buried by river action. This would account for its absence in certain cases, and it may be concluded that existing moraines in the Waimakariri Valley, and perhaps in the valleys of other rivers of Canterbury, apart from the great terminal moraines, have in most cases been deposited and preserved where they have been protected by some accident in topography, etc., from the erosion and transporting action of powerful streams. In some cases, however, existent moraines have been covered and concealed in the fans of tributary streams.

Length of the Waimakariri Glacier.

The question of the maximum length of the Waimakariri Glacier during the glacial period is bound up with the presence or absence of moraine in critical localities. The furthest distance from the divide that undoubted moraine occurs in the Waimakariri intermont is near the old homestead at Avoca, there being no signs of it on the sides of the gorge down which the railway passes towards Springfield. The chief suggestion of its extension on to the plains is the presence of mounds, perhaps morainic in origin, near the Springfield and Sheffield railway stations, and at Racecourse Hill; some 5 miles further on, and distant from the mouth of the gorge about 13 miles. Such an extension implies a wide spreading of the ice as a piedmont on both sides of the present position of the river, and even if it were of moderate thickness, the maintenance of the supply through a somewhat narrow gorge would be a matter of extreme difficulty unless the ice reached far up the slopes on either side. This seems to me a serious objection to an extension as far as Racecourse Hill, and, to a lesser degree, if Sheffield be considered the limit. However, both Haast (1879, map) and Hutton (1884, pp. 449-54) were of the opinion that the glacier reached as far, or nearly as far, as these mounds. It will be appropriate, therefore, to consider the evidence, inconclusive though it may be.

Little can be said concerning the mound near Springfield since it is now covered completely with close-growing gorse and broom, and an adequate examination is impossible, but no large blocks are visible on the surface. Hutton (loc. cit., p. 449) gives a description of the Sheffield mound, sometimes known as Little Racecourse Hill. He says, "it contains large, angular, erratic blocks washed out of some former morainic deposit, and now completely mixed with river shingle, but there is no boulder clay." The mound is now covered with soil and cultivated nearly all over, so there are no good exposures, but about the middle of the western face a collection of angular and sub-angular blocks shows on the surface with little small material among them. The largest block measured was 5ft. by 4ft. by 4ft., and there is a fair proportion of slightly smaller sizes. At one spot a mass shows just level with the surface, strongly suggesting rock *in situ*, and if this be correct, it no doubt forms a connecting link between the solid greywackes of Gorge Hill on the Waimakariri

and the slopes of Abners Head about a mile to the west of the mound. If it is not in position, then it implies a larger mass than any exposed. It seems reasonable for both Hutton and Haast to maintain that the ice extended nearly as far as this mound or actually reached it, since the blocks have retained angularity and therefore had not been carried any considerable distance by stream action.

The case of Racecourse Hill presents more serious difficulty. Hutton says that it is composed of rounded shingle like that of the plains. In my opinion it resembles in degree of weathering the older pre-glacial gravels of the Malvern Hills and elsewhere in North Canterbury rather than that of the plains, and, further, the mound is capped near the trig. station and on its northern end by concentrations of large angular and subangular blocks not as large as those of Little Racecourse Hill near Sheffield, but still up to four feet in length. The form of this hill suggests that it might be a remnant of a latero-terminal moraine of a glacier reaching so far, but Hutton says that it reminded him of the Eskers of Ireland or Kames of Scotland. It does certainly show a striking resemblance to the historic esker near Upsala in Sweden, especially as regards the concentration of large blocks on its summit. The concentration in the Swedish case is attributed to the action of the sea, but this agency is hardly possible in the New Zealand cases, though Hutton maintained that the plains in the vicinity of the mounds had been planed by the sea; he did not suggest that their summits had been planed and the large blocks concentrated by its agency.

Although no moraine to support the former presence of ice occurs on the lower slopes of the hills near Springfield, where it might be expected to occur on the analogy of the perched blocks on the slopes and summit of the Rockwood Hills near Rakaia Gorge, an assemblage of large blocks lies on the north-eastern slopes of Abners Head just above the level of the Hawkins River, and these, if of glacial origin, might be attributed to the Waimakariri Glacier if it had reached as far as Racecourse Hill, and even if it had reached Sheffield, but it is also reasonable to credit them to a distributary of the Rakaia Glacier which came down the upper Selwyn valley past the Dalethorpe homestead.

It may be urged that if a glacier extended on to the plains some definite remnant of terminal moraine should have survived. This, however, is not necessary since the glacier may have had no terminal or a very scanty one. In the latter case the blocks comprising it would be dispersed and buried like those in the outwash plain of Slovens Creek. Hutton mentions the presence of erratics in the high gravel banks near the junction of the Kowai with the main river, an observation confirmed by the present author, for an accumulation of angular masses up to 6 ft. by 4 ft. by 3 ft. in size with a large number of smaller sizes with angular and rounded edges lies at the base of the terrace in the angle between the rivers, and one especially massive boulder, 10 ft. by 10 ft. by 12 ft., with edges well rounded, lies near the top of the terrace surrounded by others of smaller size. A wash-out nearby discloses that the lower beds are composed of finer more thoroughly cemented material with a layer of coarser

material on top of it, and on this latter, or in it, occur the large masses. I have noted a tendency elsewhere in this area—and it happens also in the case of the large concrete blocks in protective works on the Waimakariri lower down the plains—for large blocks lying on loose gravel and exposed to the wash of water, to sink till they reach solid rock or a layer of more consolidated material, and this may account for the concentration of larger masses from what were originally mere sporadic occurrences in a mass of shingle, and would explain the gradual disappearance of moraine if it had been laid down on the gravel of the upper part of the plains. Moraine resting on gravel does occur now at the outlets of the Rakaia and Rangitata valleys.

The question, therefore, of the presence of ice in this vicinity depends on the power of rivers to move such large blocks. If they cannot, then under the conditions obtaining, ice must have been the only agency responsible for their position, and we must agree with Haast and Hutton that the glacier came down nearly to Sheffield, though hardly as far as the vicinity of Racecourse Hill. I have seen blocks up to 15 ft. in length in the bed of the Harper River, where it is over half a mile in width and composed of gravel, but these may have been residuals of moraines such as occur in the vicinity and are not transported blocks. The experience of engineers carrying out protective works on the Waimakariri River is in the direction of conceding the river power to move concrete blocks of similar size, and with this possibility always existent it seems dangerous to use their presence as definite proof of the extension of the glacier into the area under consideration, although it does not appear reasonable that such large blocks can have been carried far. The angularity of many of these masses also supports the contention that they have been ice-borne from some spot in close proximity to that where they are now situated.

The evidence from the north bank of the river is as unsatisfactory. If a glacier had reached as far down as Sheffield one would expect to find some remnant of moraine in the form of perched blocks on the slopes of View Hill, and I have not been able to find any either on the greywacke or on the dolerite, where the presence of foreign greywacke would be easily detected, and if found, would be convincing. Large angular blocks up to 6 ft. in diameter have been washed out of the high terrace between Woodstock and the Eyre River, and occur on its margin and on the sides of the Airlie Creek which intersects it; these are analogous to those on the south bank of the Waimakariri near the Kowai. But this terrace is not composed of ordinary river gravel for it has an important matrix of clay with angular, sub-angular, and rounded stones. None of these were observed to be scratched and the texture was not as tenacious as that shown by a typical boulder-clay or tillite, so it cannot be assigned definitely to that class of glacial deposit. Its uniform and accordant surface suggests that it has been planed from a pre-existing deposit. The terrace extends for several miles down-stream towards the Eyre River, and gradually increases in width till it is over a mile broad. It is the highest terrace in this part of the plains, and its occurrence

supports Hutton's contention that a veneer of gravel has been stripped from their surface, the mounds at Racecourse Hill, etc., being remnants of it. Although it is not analogous in character to these, it does indicate that a river issuing from the gorge or its vicinity once ran at a higher level than that of the present general surface of the plains. On the solid greywacke slopes rising from this terrace there are accumulations of large angular stones which do not appear to have been shed from the slopes above and which resemble those of the terrace just referred to. Judging from the smoothed contours of the hills in their vicinity, a distributary of the main glacier must have crossed a low part of the ridge east of Trig. Q, in the direction of the middle course of the Eyre River, and these blocks may be part of a lateral moraine of this distributary, but since they are entirely of greywacke and rest on greywacke as far as can be seen, there must be some doubt concerning their character as a glacial deposit. A stream from this portion of the ice-front certainly ran towards the Eyre.

To sum up the position as to the possible extension of the Waimakariri Glacier on to the plains, it can only be stated that either rivers are competent to move for considerable distances the large blocks occurring in the terraces, or, in the event of this competency being denied, glaciers came down nearly as far as Sheffield; but that it is extremely improbable that they came as far as Racecourse Hill. In my opinion, which after all is largely impressionist, they came as far as the line of the Kowai River and may have reached further. The problem is thus left unsolved, and awaits more detailed future investigation.

The only indications from the gorge itself that it was once occupied by ice are (1) the wide, open trough in which the present bed of the river is deeply incised, (2) the smoothed surfaces of the slopes alongside of it, and (3) the occasional triangular facets of spurs—usually a somewhat indefinite feature. The trough itself probably dates from pre-glacial times, since some stream must have discharged through this gap from the Waimakariri intermont, and it probably reached a sub-mature stage. Its form would be modified by ice-scour into its present cross-section, and on the retreat of the ice the floor would be covered from the gorge upstream with a thick veneer of gravel, remains of which now survive on the rocky shoulders above the present incised gorge. So thick is this deposit at times that many of the railway tunnels are driven in it entirely. These gravels date in all probability from the epoch of the Slovens Creek outwash plain and they grade into it. The streams issuing from the ice-front at this stage would be so heavily charged with waste that they would have little energy left over to modify the form of the ice-scoured trough by vertical or lateral corrosion. The deeply incised gorge within the gravel-masked trough is a later feature, whose formation, as well as that of the other incised gorges of the river in its vicinity, is perhaps connected in some way with an isostatic modification of the earth's crust following on the disappearance of the load of ice.

Comparison with Mackenzie Country.

Although there is some resemblance between the circumstances of the Waimakariri and those of the Rakaia and Rangitata, there is a closer parallel with those of the Mackenzie Country. In both cases there is an intermontane basin which is drained through a narrow gap in the southern or south-eastern border. Both were fed with snow and ice from valleys rising in the main divide and converging on the floor of the basin; in both cases there is opportunity for the dissipation of declining glacier energy on its floor; moraine has been formed at the end of mountain valleys when they reach the true structural boundary and where distributary tongues of ice have deployed through gaps in a broken range of hills rising from its floor (e.g. west of the road from Tekapo to Simons Pass); an outwash plain fronts the moraines in both cases; and there is a relative paucity or uncertainty of evidence, apart from smoothed outlines, to prove the extension of the ice beyond the limits of the basin. Although Haast and Park have maintained that moraine occurs in the Upper Opihi and Hakataramea Valleys as a result of the ice lapping over the south-eastern edge at the height of the glaciation, Hector and McKay considered that such moraines were not directly connected with it, but arose from independent glaciers on the outer flanks of the basin. Personally, I have seen no definite evidence that ice extended beyond its limits.

The great moraine or complex of moraines that stretches discontinuously from the lower end of Lake Tekapo in a south-westerly direction past Lake Pukaki and on to the vicinity of Lake Ohau seems to correspond in time and conditions of deposit to those of the Waimakariri near its junction with the Poulter, and those along Slovens Creek, judging from their external form, state of preservation, and degree of weathering of the morainic dumps. Both indicate a prolonged halt in the position of the terminal face, whether it be in a general retreat or in an advance from a position further back and nearer the divide.

Recession of the Waimakariri Glacier.

As the Waimakariri Glacier retreated within the intermont, it would first of all evacuate the country lying along the eastern border, approximately the belt along the line of the Puketeraki Gorge and the Esk Valley, for this part would be the first to feel the effect of any failure in the supply of snow and ice near the main divide, and especially so, seeing that no part of the Esk Valley reaches so far. Even if we include the Cox, the length drained to the Esk will be small and of little account as a feeding ground. So the valley of the Esk would feel an ice famine even while large glaciers occupied the Waimakariri and Poulter Valley, and distributaries reached to the slopes of Mount Rosa and Noman's Land. Perhaps to this time, along the high level gravels of the Puketeraki reach of the main river, those near the outlet of Slovens Creek and also the thick, flat-lying gravels of the Esk Tableland. The outwash gravel terrace of Slovens Creek belongs to a later date, after the slopes of the hills just mentioned were freed from ice. It is somewhat difficult to

indicate exactly the order in which different areas were evacuated, but it seems reasonable to place the high-level moraines between the southern end of the St. Bernard Range and Noman's Land earlier than the Slovens Creek outwash terrace, and the outwash plain south-west of Vagabonds Inn with its morainic dumps in an intermediate position, probably contemporaneous with the outwash plain in Winding Creek which is margined with moraine on its upstream side. Retreat from the junction of the Poulter began about the same time, and the fluvio-morainic deposits of St. Bernards Saddle were laid down later and the moraines south of the Sugarloaf near Lake Sarah later still. The low-level moraines at the lower end of Lake Pearson probably date from the period before the evacuation of the lower end of the Waimakariri trough had begun, but this cannot be stated for certain. The Winding Creek-Lake Pearson-Cass area would no doubt be free from ice or but lightly occupied in its northern portion, while the Waimakariri trough was still well filled, since the latter would have important feeders direct from the main divide while the former would have its supply obstructed by the Mount Misery-Goldney Saddle ridge just north-west of Cass. That this area was partly, if not entirely, freed from ice while the main Waimakariri was still occupied is proved by the position and features of the moraines south of the Sugarloaf for they clearly indicate that ice came round the southern flanks of this hill from the direction of the main river. The moraines which cross the above-mentioned valley are stadial of one episode of glacier retreat or of retreat after a re-advance, most likely of the former.

The further retreat to the present position must have been very rapid, since there are no moraines in the upper reaches of the valleys tributary to the Waimakariri till near their heads. This rapid retreat is perhaps contemporaneous with that of the ice margin through Southern Sweden from the Weichsel (Würm) moraine of northern Germany. It should be pointed out that the present glaciers do not necessarily mark a halting stage in the retreat from the Pleistocene position, but really indicate an advance from a line further back than that occupied now, since there is definite evidence that following the Pleistocene glaciation there was a time when the climate of southern New Zealand was much milder and more rainy than at present (Lucy Cranwell and F. von Post, 1936, pp. 308-47). In this respect the sequence of events corresponds closely with that obtaining in Scandinavia following on the great recession of the ice.

Apart from this, the only definite evidence of more than one ice advance after retreat is furnished by the Winding Creek Valley. In this case there are certainly two, perhaps three, episodes of glacier advance, for the fact that moraine rests above varved silts is definite proof of retreat and re-advance. The great moraines indicate that the ice-front was stationary for long periods, but these may have been for periods during a general retreat when the ice was holding its own, and do not indicate an advance from a position further back towards the divide.

The only other evidence of more than one period is furnished by the shelves cut in the sides of the valleys, usually in series of two

or three as along the flanks of Noman's Land. Sometimes there are more, as for example on the hillsides south-east of the Craigieburn homestead, where there are four, perhaps five. These may, however, have been cut during one glacial episode and do not indicate several advances and retreats.

In concluding this account I have to express my sincere appreciation of the assistance rendered to me on many occasions by Mr. William Izard, of Enys, Castle Hill, for without his help the examination of the area concerned would have been most incomplete. I have also to thank Mr. Les. Hill, of Kaiapoi, for the print of Lake Blackwater and its associated moraines.

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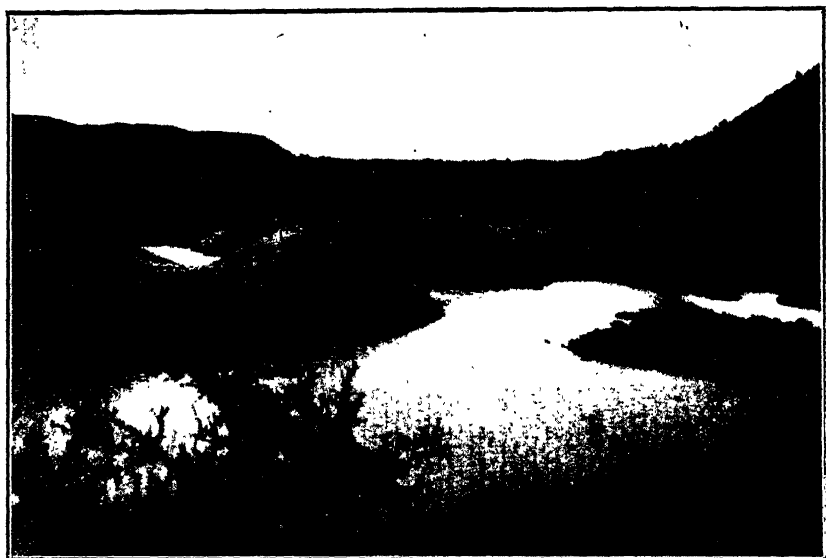


PHOTO. No. 1.—Lochinvar Moraine, showing glacial dumps, with Lake Gracie ponded in the hollows.



PHOTO. No. 2.—Lochinvar Moraine, frontal portion, with smaller morainic dumps; valley of the Cox in background, slopes of the Candlestick Mountains on right.

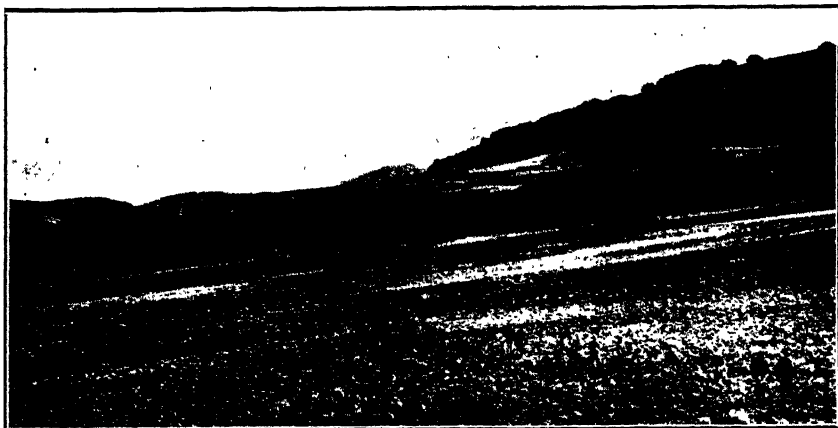


PHOTO. No. 3.—Moraines south-west of Lake Blackwater, in foreground bed of old glacial stream flanked with river terraces, the bed now carrying little water; on right are ice-scoured slopes.



PHOTO. No. 4.—Lake Blackwater in foreground, moraine in middle distance; Poulter Valley, Mounts Peveril and White in distance.

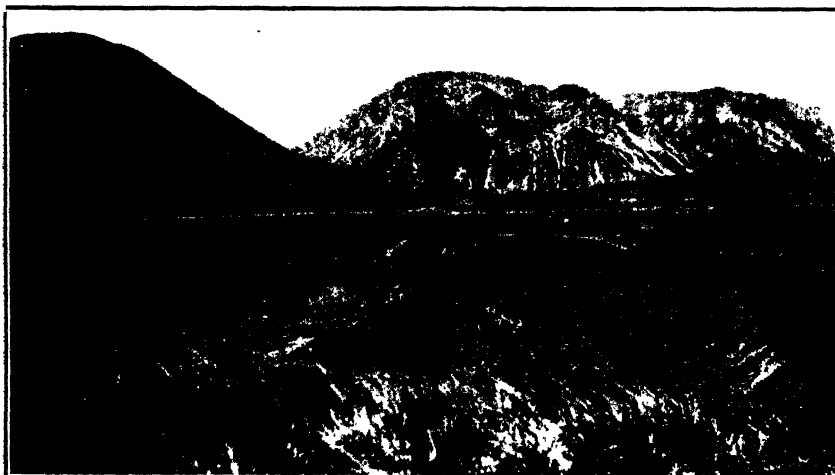




PHOTO. No. 6.—Looking up Winding Creek towards St. Bernard Range; high level morainic terraces against mountain on right; areuate younger moraine in middle distance; breached by stream on left; ends of spurs clearly faceted.



PHOTO. No. 7.—Moraine between Lakes Pearson and Grasmere; St. Bernard Range with ice-scoured slopes on right; the ridge on the left has also been scoured by ice.

The Calyptrate Diptera of New Zealand, Parts VIII and IX.*

By JOHN R. MALLOCH.

(Communicated by D. Miller.)

[Read before the Nelson Philosophical Society, October 27, 1936; received by the Editor, March 10, 1937; issued separately, September, 1938.]

PART VIII.

IN the present paper, which may be my final one of this family for the country, I present descriptions of a large number of new genera and species and also a preliminary key to the genera of New Zealand. Press of other work has delayed the completion of this paper and changed conditions here may interfere with a continuation of my studies on the family.

I have, I hope, been able to lay the foundation of a more reliable system of identification of these important insects for more complete work by resident students interested in them, but it must be distinctly understood that I have absolutely no field information on the material upon which this paper is based, and that I am not at all satisfied that there will be found to be the same cleavage between genera now included herein when more species are discovered, as they undoubtedly will be. It is very difficult to distinguish satisfactorily many of the rather closely related concepts in this country, and later on with the accession of more data it may be that a more conservative attitude towards them will be adopted and a number of what I now call genera may be lumped together on the basis of characters not made use of by me as indices to groupings.

To put it rather bluntly, my main object has been to make it possible for any entomologist who has a fair knowledge of insect anatomy and the terms used in descriptions of these insects to indentify at least a large percentage of the species. That, in my opinion, is or should be the ultimate object of such studies as this; and the more pretentious aim of presenting what one might claim to be a natural system of classification is, on the basis of such a collection as is available to me, impossible of attainment. I do think, however, that the great majority of the New Zealand species have been derived from one or two common ancestors, and that comparatively few of the existing genera are closely related to even those of Australia.

I have to thank Prof. R. Speight of the Canterbury Museum for sending to me the Hutton types, Dr David Miller for the loan of his collection, forwarded to me by Mr. E. S. Gourlay, and also several correspondents who have in the past sent me material in the family which has considerably aided me in the preparation of this paper.

* Pts. i-vii in *Records Canterbury Museum* (1926-32).—D. M.

Genus *WATTIA*, novum.

A peculiar genus with some of the characters of *Doddiana*, Curran, particularly the fused abdominal tergites and yellow general colour. It differs from it in the presence of setulae on the parafacials, in having the first posterior cell of the wing closed and with a short petiole, and in having the second segment of the arista over one-third as long as the third.

Genotype, the following species:—

Wattia ferruginea, n.sp.

Female entirely ferrugineous yellow and dull, the antennae more orange-yellow, all parts more or less noticeably yellow dusted, the mesonotum with traces of four darker ferrugineous vittae, the dust on the abdomen variable according to the angle from which it is viewed, the wings yellowish, veins darker apically, and with narrow yellow margins on the paler parts.

Length, 7 mm.

Head in profile as Fig. 1. Frons at vertex two-fifths of the head width, widened to anterior margin, its length in centre about equal to its width at verticals, the orbits at middle fully half as wide as the interfrontalia, the vertex rounded, vertical transverse, the outer pair about half as long as the inner, postverticals shorter and finer than the ocellars, about equal to several setulae on the occiput and not longer than the uppermost one of the series of four or five rather widely spaced upper postocular setulae, the ocelli slightly in front of the verticals. In addition to these characters the interfrontalia has some scattered setulae, the uppermost of the inner marginal orbitals is reclinate, the two at the anterior extremity of that series are almost transversely placed, and the outer proclinales are three in number, the two upper bristles more or less outwardly sloped. The face is flat and the eyes are bare.

Thorax with the bristles strong and the hairs very sparse. Dorsocentrals 3 + 3 acrostichals 2 + 3, the posterior pair of presuturals well in front of the suture; prealar rather long but not very strong; presutural intraalar short and fine, the postsuturals 3; sternopleurals 3, very closely placed; three bristles on the lower edge of the propleura, and one stigmal; scutellum with eight marginal and two discal bristles, the apical pair of former much shorter than the one on each side of them and parallel; postscutellum extending to apex of scutellum; no fine hairs below lower squama; pteropleural long and strong; prosternum small and bare. There are no erect hairs or bristles on the scutellum and the anterior margin of the mesonotum has a number of strong erect setulae, the small bristle in line with each series of the dorsocentrals the strongest. Propleura bare in centre.

Legs strong, with strong bristles, the tarsi of all pairs longer than their tibiae. Fore tibia with three or four bristles on the anterodorsal and posterodorsal surfaces and two on the posterior; mid-tibia with two anteroventral and posteroventral and four or five anterodorsal and posterodorsal bristles, the anterodorsal series much the longest and strongest; hind femur with a dorsal and an anterodorsal series.

of bristles on apical half or more, a widely-spaced series of uneven bristles on the anteroventral surface; hind tibia with about half a dozen bristles on the anterodorsal and posterodorsal surfaces and three or four short anteroventral bristles.

Wings rather narrow, third vein setulose at base below and from base to inner cross vein above, first posterior cell with a short petiole, ending slightly before wing tip, the angle of fourth vein sharp, the section of vein beyond it much bent in just above the angle (Fig. 2); inner cross vein about four-sevenths from base of discal cell; outer cross vein about two-fifths from bend to inner cross vein; sixth vein complete. Costal thorn undeveloped.

Abdomen ovate, evenly rounded above, the sutures between the tergites distinct only at the lateral curves; first visible tergite without apical central bristles, second with two or three pairs of discals and an apical central pair, third with two pairs of discals and a complete apical series, fourth with a discal transverse series and a weaker apical series; the segments all with bristles at the lateral curves. Second sternite with a pair of apical bristles.

Lower squama lobate, its inner margin lying against the side of the scutellum and its apex quite broadly rounded.

Holotype, Wanganui (M. N. Watt).

I dedicate this genus to Dr. M. N. Watt, who sent me the type specimen several years ago.

This is one of the few endemic New Zealand genera of the family known to me in which there are no setulae or hairs below the lower squama on the postnotum. I am placing in this same genus some additional specimens which I have distinguished as species on the following characters:—

- | | |
|---|---------------------------|
| 1. Costal spine lacking; apical pair of scutellar bristles about half as long as the next pair; apical part of wing venation as Fig. 2. | <i>ferruginea</i> , n.sp. |
| Costal spine well developed; apical pair of scutellars lacking or very short. | 2 |
| 2. Apical pair of scutellars present; apical part of wing venation as Fig. 3. | <i>petiolata</i> , n.sp. |
| Apical pair of scutellars lacking; apical part of wing venation as Fig. 4. | <i>sessilis</i> , n.sp. |

Wattia petiolata, n.sp.

Female similar to *ferruginea* in general colour and structure, the antennae bright orange-yellow, and the thorax without definite vittae on dorsum.

Differs in having the apical pair of scutellar bristles very small and cruciate, the presutural area with three pairs of acrostichals, the lower costal spine fully as long as the inner cross vein and the upper one distinct though much smaller, the petiole of the first posterior cell of the wing much longer (Fig. 3), both cross veins with rather evident brown clouding, and the dust on the abdomen less evident.

Length, 8.5 mm.

Male. A male specimen which I take to belong to this species is darker in colour, the thorax being almost fuscous, and the parafacials much narrower and with finer bristles. The third antennal segment is also much wider than in the female, being almost half as wide as long. The abdomen is narrower, more nearly cylindrical, with longer and stronger bristles on the dorsum, and numerous erect finer bristles on the tergite in front of the hypopygium. The hypopygium is of moderate size, with long tapered forceps which are directed forward between the processes of the fifth sternite. The outer cross vein is almost straight, but otherwise the characters are as in the female.

Length, 6 mm.

Holotype ♀, Mt. Arthur, 4,500 ft., 21.xii.21 (A. L. Tonnoir); allotype, Arthur's Pass, 3,200 ft., 1.i.23 (J. G. Myers).

***Wattia sessilis*, n.sp.**

Female. A smaller and darker species than either of the other two in this sex, with the thorax except the scutellum fuscous and slightly grey dusted and the abdomen glossy brownish yellow, the sides below greyish dusted.

Structurally different from *ferruginea* as noted in the above diagnosis and in having the parafacial bristles more numerous and stronger, the scutellum with six long strong marginal bristles and no short pair between the apical pair of these, the mesonotum with but two pairs of presutural acrostichals, and the first posterior cell closed only at its apex (Fig. 4).

Length, 6 mm.

Holotype, Cass, Nov., 1924 (A. L. Tonnoir).

I may be in error in my association of the male above described, which may belong here, or to a fourth species.

Genus GENOTRICHIA, novum.

Similar to the preceding genus in general characters, differing in having the sutures between the abdominal tergites all distinct throughout their width, the outer cross vein of the wing not beyond midway from inner to the bend of fourth, and the first posterior cell with a longer petiole and different course of fourth vein beyond the preapical angle. The head is very much like that of *Wattia*, but the third antennal segment is more widened at apex. In other respects similar to that genus.

Genotype, the following species.

***Genotrichia tonnoiri*, n.sp.**

Male. Head dirty testaceous yellow, frontal orbits, ocellar spot, and occiput above blackened; antennae black, apex of second segment reddish. Profile as Figure 5. Frons at vertex almost half as wide as head, widened anteriorly, with the same bristling as in *Wattia* except that there are no incurved setulose hairs or bristles on the interfrontalia such as are always present in that genus. Second segment of the arista at least half as long as third. Palpi testaceous, with some setulose hairs on their lower sides.

Thorax glossy black, humeral angles and lateral margins of the mesonotum with grey dust, no vittae evident. Bristling as in *Wattia* except that the scutellum has a pair of incurved bristles at base slightly above the edge, and beyond these four long strong bristles on each side, the central pair, or apicals, shortest.

Legs brownish yellow, femora variably infuscated, tarsi black. Armature as in *Wattia*.

Wings greyish hyaline, veins brown, paler at bases. Third vein setulose as in *Wattia*, but the setulae longer and stronger, the costal spine well developed, and the apical venation as in Figure 6.

Abdomen glossy black, brownish below at apex, cylindrical, bristled as in *Wattia*, with all sutures quite distinct even in centre.

Squamae yellowish hyaline. Halteres brown.

Length, 6.5 mm.

Holotype: Mt. Arthur, 5,000 ft., 23.xii.21 (A. L. Tonnoir).

I have also what appears to me to be a second species of this genus which is described below. Possibly some workers on the family would consider that it should be given generic segregation, but I feel I am unable to do this because of a lack of material in both sexes and particularly because of the paucity of information as to the conditions under which these isolated specimens were taken.

***Genotrichia minor*, n.sp.**

Female. Similar in general colour to the genotype, but the coxae are much paler, being, like the femora, fulvous yellow, and though the femora apically and the tibiae are more brownish, neither is as dark at any part as the tarsi. The head is the same in markings, the lower half of the occiput being yellow as in *tonnoiri*, but the antennae are not as dark, the second segment being largely reddish and the base of third segment also largely of that colour.

The head is much less strongly bristled, the parafacials having only two or three fine bristly hairs present, most noticeably so below, the antennae are smaller and the third segment is less widened at apex, while the arista is shorter, with the second segment much less than half as long as third.

The scutellum has the bristles much less evenly developed, but in the same number, and the abdomen lacks the pair of discal bristles on the second visible tergite.

The setulae on the third wing vein are carried well beyond the inner cross vein, in fact to level of the outer one, which latter is about twice as far from the preapical angle of fourth as it is from the inner cross vein instead of but slightly nearer to the latter than to the angle. The angle of fourth vein has also a spur vein and the sixth vein is traceable to the margin though it falls short of it in *tonnoiri*.

Length, 3.75 mm.

Holotype: Cass, 28.xi.24 (A. L. Tonnoir).

There is probably some sexual dimorphism in these two genera, but I believe I am correct in my specific decisions.

Genus *ARTHURIA*, novum.

Another genus of the same general structure as the two already dealt with, the head being very similar in armature and the arista with the second segment elongated. The abdomen has the tergal sutures complete, and a pair of discals of the second and third visible tergites as in *Genotrichia*. The main distinctions are to be found in the lack of but one or two setulae at the extreme base of the third vein both above and below, one of those above being generally rather long, and the presence of four instead of but three sternopleural bristles. In all the available specimens the outer cross vein of the wing is slightly nearer to the inner cross vein than to the angle of fourth, the petiole of the first posterior cell is long, and the sixth vein is complete. As in the other two genera there are no hairs below the lower squama. A character that appears to link this genus with the *Voria* group is the pair of upwardly directed apical bristles of the scutellum, this being different from the rule in the two preceding genera in which when these bristles are present they are directed backward. A unique feature of the genus is the entire lack of short hairs on the central stripe of the abdominal dorsum between the paired bristles. The two genera already dealt with have these hairs present.

Genotype, the following species:—

***Arthuria dimorpha*, n.sp.**

Male. Glossy black, antennae and palpi black, tibiae brownish yellow, wings and squamae brownish hyaline, the veins brown, slightly clouded.

Head in profile as Figure 7. Parafacials and genae greyish dusted. Width of frons at vertex nearly half that of head, widened in front, its length in centre less than its width at vertex, the frontal orbits at level of anterior margin of interfrontalia about two-thirds as great as latter, bristled as in the other two genera, the interfrontalia without hairs or bristles. Eyes bare.

Thorax with the same bristling as in *Wattia*, including one or more bristles at centre of mesopleura above, and the long pteropleural, but with an additional sternopleural between the upper two, and the apical pair of fine bristles on the scutellum upcurved. Humeral angles and pleura slightly grey dusted.

Legs as in *Wattia*.

Wing with the apical venation as in Figure 8. Costal thorn distinct.

Abdomen glossy black, ovate, and almost cylindrical, the sutures distinct, and the armature as in *Wattia*, the fourth visible segment with long bristles on entire dorsum, becoming shorter apically. Inner edges of the processes of fifth sternite with some fine bristly hairs directed apically.

Female. Differs from the male in having the second antennal segment reddish, the palpi and legs except their tarsi brownish to fulvous yellow, and the thorax and abdomen more or less evidently grey dusted.

The antennae are not as wide, and the second arisal segment is about half as long as third.

In some specimens there is a distinct spur vein at the bend of fourth.

Length, 4-5.5 mm.

Type Male; allotype and 3 paratypes, Mt. Alpha, 3,600 ft., 19.xi.21; paratype females, Mt. Arthur, 4,500 ft., 21-26.xii.21 (A. L. Tonnoir); Purakanui (D. Miller).

The sexual dimorphism in this species is very marked, both in the colour of the palpi and legs and in the difference in size of the antennae.

Genus UCLESIELLA, novum.

This genus belongs to that artificial group in which the ultimate section of the fifth wing vein is more than half as long as the preceding section and the outer cross vein is markedly nearer to the inner than to the bend of the fourth vein. In this last character it is similar to *Arthuria minor*, but in the latter the ultimate section of the fifth vein is markedly less than half as long as preceding one. Aldrich a few years ago reviewed all the known genera with the wing characters of the present genus and the key he presents does not enable me to place it in any already described concept.*

If we are to accept this placement the genus will run down to *Uclesia*, Girschner, which is reported from Europe and Western North America. But the parafacials are not merely haired but strongly bristled, and the gena is not more than half the eye height as is shown in the accompanying figure (Fig. 9). Aldrich has described the American species, which is largely yellow, and though it has some distinct parafacial bristles there are some hairs below the lower squama which is not so in the present genus. The ultimate section of the fifth vein in his species is also as long as the penultimate while in the genus now described it is not much over half as long.

Genotype, the following species:—

Uclesiella irregularis, n.sp.

Male, Female. Black, glossy, the face and parafacials slightly grey dusted, most noticeably so in the female, the thorax almost without dusting in the male, slightly grey dusted in female, more noticeably so on the pleura. Antennae and palpi black. Legs black. Wings slightly smoky, veins fuscous and slightly margined with darker colour than the remainder of the cells. Squamae white. Halteres fuscous.

Male. Head in profile as Figure 9. Frons almost as in the next preceding genus, the orbits narrow above, widened to above antennae where either is wider than the interfrontalia, the latter without hairs; ocellars strong, proclinate and divergent; postverticals short and fine, erect and parallel. Eyes bare.

Thorax with 2 + 3 dorsocentrals and acrostichals; sternopleurals 3, closely placed; mesopleura with one or more central bristles above; prealar very small, the bristle behind it very long; scutellum with six

* *Trans. Amer. Ent. Soc.*, 52, 7 (1926).

marginal bristles, the basal and apical pairs shortest, the apicals cruciate, the disc with a number of erect fine bristles; pteropleura without a differentiated bristle, with some setulose hairs. No hairs below the lower squama.

Legs stout, tarsi slightly longer than their tibiae, the bristles strong and in the usual arrangement of this section.

Abdomen cylindrical, tapered slightly at base and apex, the suture between the first two tergites complete and better developed than either of the other two; the third suture very faint, but traceable, centrally. Second and third visible tergites each with a pair of strong discal bristles, second with a pair at apex in centre, third with a widely spaced apical series, fourth with two transverse series that are not as long as those on the preceding segments, and a series of setulae on apex that are directed backward. The hypopygium concealed.

Wing with the apical venation as in Figure 10, the ultimate section of the fifth vein about two-thirds as long as the preceding section, and the lower costal spine longer than the inner cross vein. First vein not bristled, third with bristles from base to about middle of first posterior cell on upper side, and with two or three fine setulae at extreme base below.

Female. Differs from the male in having the third antennal segment narrower, the second segment of the arista about one-third as long as the third, the abdomen more tapered apically, and the fore tarsi a little thicker.

Length, 3.5-4.5 mm.

Holotype Male, allotype, and two paratypes, Otira, 9.ii.22 (A. L. Tonnoir). One much damaged male from Ohakune, taken by M. Harris, appears to be this species.

This genus has much the appearance of *Calcageria*, Curran, but the latter has the first wing bristled above, no strong genal bristles, and the first tergite of the abdomen with a pair of strong apical bristles. Both genera have erect discal bristles, the pteropleural bristle not differentiated, and hairs on the centre of the abdominal dorsum between the discal bristles.

It may be pertinent to note here that *Heteria*, Malloch, has some of the characteristics of this group, but it differs from all of those dealt with above in having the basal segment of the arista much elongated, usually as long as the second; in all those included above the basal segment of the arista is not or hardly longer than thick.

Genus *PLAGIOMYIA*, Curran.

1927. *Ent. Mitt.*, 16 (5), 442.

This genus was erected by Curran for the reception of *Calcager turbidum*, Hutton. In his description Curran compared it with *Metaplagia*, Coquillett, distinguishing it therefrom by the wide facial depression. The other characters given consist of the equally long second and third antennal segments, the haired parafacials, the elongate second segment of the arista, and the presence of three pairs of proclinate outer orbital bristles, etc. The other characters than

those just mentioned are such as we find in *Uclesiella* and *Calcageria* except that the first vein is bare as in the former while in *Calcageria* is bristled centrally above. No mention was made of the lack of discal abdominal bristles nor of the peculiar apical venation of the wing (Fig. 11) and he was in error in stating that the ultimate section of the fifth vein is as long as the penultimate section. The ultimate section of the fifth vein in Hutton's type male now before me is not over two-thirds as long as the penultimate one. It is upon the lack of discal abdominal bristles that I base the distinction of the genus from any of those already dealt with in this paper.

KEY TO THE SPECIES.

1. Parafacials microscopically haired above, bare below middle; third antennal segment shorter than second (Fig. 12); second visible tergite in male with a pair of weak short bristles in centre of apex, the female lacking these, and both sexes with a complete apical series on third tergite; tarsi longer than usual, those of female most noticeably so, the fore pair much longer than their tibiae and the fourth segment longer than the fifth. *longipes*, n.sp.
- Parafacials longer haired, and to almost lower level of the eyes; fourth segment of all tarsi shorter than the fifth. 2
2. Gena over half as high as eye (Fig. 13); third antennal segment about 1.5 times as long as second in male. *alticeps*, n.sp.
- Gena not half as high as eye. 3
3. Third antennal segment distinctly longer than second (male about twice, female about 1.5), the second not noticeably pale at apex (Fig. 14); second visible abdominal tergite of both sexes without apical central bristles, those on apex of third and fourth in male quite strong, of female very fine and weak. *longicornis*, n.sp.
- Third antennal segment not longer than second in either sex. 4
4. Male with a pair of strong apical central bristles on second visible tergite of abdomen. *turbidum* (Hutton)
- Male without a pair of strong apical central bristles on second visible tergite of abdomen. *achaeta*, n.sp.

***Plagiomyia turbidum* (Hutton).**

A shining black species with distinct grey dust on head, thorax, and abdomen. Antennae black, second segment red at apex; palpi black. Mesonotum with four black vittae. Bases of abdominal tergites rather broadly pale grey dusted. Legs black. Wings brownish hyaline, darker along costa basally, veins dark brown, not clouded. Squamae white. Halteres fuscous.

Frons much as in *Wattia*, but the outer bristles on each orbit consist of one upper outwardly curved bristle and from three to five anterior proclinate bristles, the latter sometimes very unequal in lengths. Interfrontalia with a few minute hairs close against each orbit, none on centre. Parafacials with numerous fine hairs which extend downward to level of uppermost setulae on the facial ridges, the latter ceasing at lower third. Genal bristles rather strong, three or four in number. Third antennal segment about equal in length to second, the latter with numerous short bristles on upper side.

Dorsocentral and acrostichal bristles 3 + 3, prealar rather short, presutural intra-alar well developed, postsutural intra-alars and sternopleurals 3, pteropleural very short or undeveloped; scutellum with three marginals, the apical pair cruciate, the discal setulae long and erect, the apical pair longest.

Legs stout, strongly bristled, all tarsi at least as long as their tibiae, the fore pair of female slightly widened, fifth segment on all pairs longer than fourth.

Wing venation slightly variable, but generally as in Figure 11, the section of costa between apices of second and third veins slightly more direct or straightened than usual; ultimate section of fifth vein very faint, over two-thirds as long as penultimate one; setulae on third vein extending to well beyond inner cross vein above, and confined to node below.

Abdomen ovate, more flattened above than in any species already dealt with in this paper, all tergites with lateral bristles, first without, second with a pair of apical central bristles, third and fourth with complete apical series, fourth with no discals and with a series of bristly hairs on apical edge that extend backward. Both pairs of the hypopygial forceps of male tapered to apices and slightly bent forward at tips, the superior pair more slender than inferior pair. Fifth sternite of male with a number of long bristly hairs on lower edges of the processes.

Length, 6-7 mm.

I have before me Hutton's type male from Christchurch and a male and female from the same locality taken by Dr. Tonnoir. Additional localities are as follows: Cass, Ohakune, Spreydon, Nelson, and Mt. Grey.

***Plagiomyia achaeta*, n.sp.**

Male. Similar in all respects to *turbidum*, except in having the antennae without distinct red apex to the second antennal segment and no pair of strong bristles in centre of apex of the second visible tergite of the abdomen of the male.

Length, 6 mm.

Holotype, Mt. Arthur, 5,000 ft., 23.xii.21 (A. L. Tonnoir).

It is possible that this is merely a dark and small variety of *turbidum*, as in some females the second visible tergite of that species lacks the apical central pair of bristles, and it is not unreasonable to expect that occasional males may vary in the same manner from the typical form.

***Plagiomyia longipes*, n.sp.**

Female. Similar to *turbidum* in general characters, colour, etc., differing from it in having the parafacials narrower in profile, more evenly brown dusted and with smaller hairs and more confined to the upper half (Fig. 12), the antennae with the third segment shorter, no pair of apical central bristles on the second abdominal tergite, and the fourth tarsal segment on all legs longer than the fifth. Otherwise almost identical.

Length, 6-7.5 mm.

Holotype, Mt. Arthur, 4,500 ft., 21.xii.21 (A. L. Tonnoir).

***Plagiomyia alticeps*, n.sp.**

A more densely grey dusted species than any of the others, the head except the antennae being entirely so, the mesonotum showing but faint traces of the dark vittae, and the basal tergal grey dusted fasciae of the abdomen much wider, while the genae seen from behind against the light are rather bright red.

Structurally it differs from the others in the higher genae and the longer third antennal segment as well as the different arrangement of the orbital bristles (Fig. 13). The genal bristles are undeveloped and there are many more fine bristles on the vibrissal region than usual.

The abdomen has a strong apical central pair of bristles on the second visible tergite as in *turbidum*, but there are more numerous setulose hairs at the apex of the fourth tergite that give the abdomen a rather tufted appearance.

The setulae on the upper side of the third wing vein are also weaker, and they do not extend to the inner cross vein.

Length, 7 mm.

Holotype, Male, Ohau Beach, 23.x.16, No. 1177 (D. Miller).

***Plagiomyia longicornis*, n.sp.**

A smaller species than any of those already dealt with in the genus, with much the same general characters and colouration as *turbidum*, differing noticeably in the entirely black and much longer third antennal segment (Fig. 14). The male also lacks the apical central pair of bristles on the second visible abdominal tergite, and in both sexes the outer cross vein is closer to the inner than to the bend of the fourth vein. The male hypopygium is similar, and in one male there is a long spiral thread-like organ protruding much as in the male of *Voria*.

Length, 4-5.5 mm.

Holotype and allotype, mounted on same pin and evidently taken *in copula*, Nelson, 7.xii.21 (A. L. Tonnoir). Paratypes, Nelson, February, 1929, one female labelled "running on ground, apparently unable to fly" (A. L. Tonnoir); one female, Ohakune, 30.x.19 (Harris).

The female that could not fly is immature and that no doubt accounts for this unusual feature.

One specimen from Okarahia, taken by Mr. Tonnoir, is larger than the holotype, but does not materially differ as far as I can determine, though the outer cross vein is closer to the angle of the fourth vein than to the inner cross vein.

Another male from Mt. Arthur lacks grey dusted fasciae on the abdomen, but it is structurally similar to the holotype and may be greasy.

Genus *Calcageria*, Curran.

1927. *Ent. Mitt.*, 16, No. 6, p. 442.

This genus was distinguished from *Calcager*, Hutton, in the following manner: "Similar to *Calcager*, Hutton, but the eyes bear very sparse, short hair, the parafacials are strongly bristled, the

apical cell ends farther from the apex of the wing, and the last section of the fourth vein is hardly bowed inwards."

Genotype, *Calcageria incidens*, Curran.

I have before me four species, the types of this genus and *Calcager*, and what I take to be two new species, and a careful examination of these, all of them represented by more than a single specimen, causes me to believe that it will be either necessary to merge the two existing genera or to erect at least one additional genus. The presence of strong setulae or bristles on the upper surface of the first wing vein was not listed as a generic character for *Calcageria* by Curran, possibly because there may have been some doubt in his mind as to the importance of this as a generic character, but it has been used in the family as a generic criterion, and it appears to be of considerable value in some groups. It is undoubtedly, in my opinion, more important than the hairs of the eyes or the trivial distinctions in the venation of the wings made use of by Curran in his generic diagnosis. I have elected to make use of the bristled first vein as the distinguishing character herein, and separate two species on the characters given in the following diagnosis:—

- A. One or more of the parafacial bristles as long as the arista; palpi entirely testaceous yellow; at least the hind tibia reddish yellow centrally; fifth wing vein without bristles on upper surface. *incidens*, Curran
- AA. None of the parafacial bristles nearly as long as the arista; palpi fuscous. all the tibiae black; fifth wing vein almost invariably with one or more bristles on upper surface near base. *varians*, n.sp.

Calcageria incidens, Curran.

This species is black, rather densely grey dusted, with the basal two segments of the antennae and the palpi testaceous to fulvous yellow, and the tibiae more or less distinctly reddish yellow or brownish yellow centrally. Thorax with grey dust, the mesonotum with four black vittae, abdomen glossy black, the base of each tergite rather broadly pale grey dusted. Wings brownish hyaline, veins fuscous. Squamae brownish hyaline. Halteres brown.

Head of female as Figure 15 in profile. Eyes with some scattered pale hairs of moderate length but difficult to see unless at certain angles against the light. Frons wider in front than its length in centre, the triangle and orbits grey dusted and the interfrontalia reddish brown, the latter with one or two hairs on each side centrally; outer proclinate bristles on each orbit usually three, the upper one or the central one weakest.

Dorsocentrals 3 + 3 acrostichals 3 + 2, prealar short, postsutural intra-alars 3, presutural intra-alar well developed, pteropleural very short, sternopleurals 3; scutellum with 3 laterals on each side, the apical pair rather short and cruciate, the disc with a number of erect bristles.

Legs stout, tarsi slightly longer than their tibiae and rather thick, the fourth and fifth segments subequal, bristling strong and arranged as in the other genera.

Wings rather small, the apical venation as Figure 16, first vein strongly setulose centrally above, third setulose from base to well beyond inner cross vein above and at extreme base below, inner cross vein beyond middle of the discal cell, outer nearer to inner than to angle of fourth, ultimate section of fifth vein about three-fourths as long as penultimate.

Abdomen subcylindrical, tapered at apex, the sutures entire, the one between first and second visible tergites most distinct. First visible tergite without a pair of apical central bristles, the second and third with these bristles and a strong and usually a very weak pair of discals, fourth with a preapical series of strong and a discal series of much shorter bristles and the usual backwardly directed series of bristles and hairs on the hind margin.

Length, 6.5–7 mm.

Localities, Ruapehu and Kaikoura. Originally described from Wellington and Auckland. Type in Berlin.

***Calcageria varians*, n.sp.**

A darker species than *incidens*, with the antennae, palpi and legs entirely black.

Structurally the species differs markedly from the genotype as follows: the frons is a little narrower, each orbit has but two proclinate outer bristles, both long and strong, the parafacials are narrower, with more closely placed and much weaker and shorter bristles, the genae are not as high and have no strong bristles behind, the abdomen is more nearly cylindrical with longer dorsal bristles, and the first visible tergite has a long, strong, erect pair of bristles at apex in centre. There are two rather remarkable features of the species which in one or two specimens do not conform to the general rule, but they are sufficiently constant to make them worth recording. The first is the presence of but a single erect bristle near the apex of the scutellum on its upper surface. Usually bristles occur in pairs in this family, and most others, especially on the thorax and abdomen, and this is a remarkable exception. The other character is the presence of one or more bristles on the upper surface of the fifth wing vein near the base of the discal cell. In 12 out of 14 specimens this character holds. It is also the case that the outer cross vein is usually nearer to the bend of the fourth than to the inner cross vein, but there is some variation in this character so that one cannot depend upon it in individual examples.

Length, 6.5–7.5 mm.

Holotype and allotype, Cobb Valley, 10.xii.22. Paratypes, Dun Mountain, 19.i.31, 14.ii.26 (E. S. Gourlay); Mt. Grey, April, 1920 (Lindsay); Otira, 20.xi.19 (Miller); Nelson, October 17. Aniseed Valley, 1–4.xii.23, Cass, 1.xii.24 (A. L. Tonnoir).

Genus CALCAGER, Hutton.

I have before me the type-specimen of the genotype, *apertum* Hutton, kindly sent to me for examination by Dr. R. Speight. I also have a number of specimens of the species that agree closely with it, and am able to determine that there is some variation in certain

characters within the species. It is unfortunate that I have males only of *apertum*, and females only of the other two species I am placing in the following key.

KEY TO THE SPECIES.

- | | |
|--|---|
| 1. Cross veins of the wings not clouded; basal two segments of antennae, and the palpi, orange-yellow, the tibiae mainly reddish yellow; postsutural dorsocentrals 3; costal spine well developed; setulae on third vein continued to about level of the outer cross vein. . . | <i>Calcageria incidens</i> ,
var. <i>nuda</i> nov. |
| Cross veins and fourth vein at preapical angle conspicuously clouded with fuscous. | 2 |
| 2. Costal thorn long; legs entirely black, palpi usually so; postsutural dorsocentrals 4. | <i>apertum</i> Hutton. |
| Costal thorn undeveloped; tibiae largely reddish yellow; palpi orange-yellow; postsutural dorsocentrals 3. . . | <i>dubium</i> , n.sp. |

Calcager apertum, Hutton.

A rather large shining black species, with white dust on head, thorax and abdomen, the basal two antennal segments usually reddish yellow and the palpi fuscous. In exceptional specimens the antennae are darker and in one specimen the palpi are brownish yellow. The thorax has four black vittae, and the bases of the abdominal tergites are silver white dusted, the fascia on the fourth tergite usually drawn out into a point in centre. The conspicuous clouds on the two cross veins and the preapical angle of the fourth are characteristic of this species and the next one in this group, and remind one of certain African species of the genus *Sarcophaga*.

The third antennal segment is rather variable in length as compared with the second, usually equal to the latter in length, it may be in some specimens quite noticeably longer. The second segment of the arista is also variable in length, but is always at least three times as long as thick. The proclinate outer orbitals are strong and usually in three or four pairs. There are usually two or three rather strong posterior genal bristles, and the parafacials are furnished with numerous moderately long setulose hairs. The eyes are quite densely pale haired.

This is the only species of the group I am dealing with in this paper that has four pairs of postsutural dorsocentral bristles. The scutellum has a number of long erect discal bristles, the pair nearest apex the longest.

Legs normal, with the usual strong bristles.

Wings as usual rather small, hardly attaining the apex of the abdomen, with the apical venation similar to that of *Calcageria*, though the outer cross vein is rarely proximad of midway from inner to angle of fourth, and the fourth beyond the angle is more markedly incurved immediately above the angle. There are rarely more than one or two bristles beyond the inner cross vein on upper side of third vein, and the ultimate section of the fifth vein is hardly half as long as the penultimate one.

Abdomen cylindrical, tapered to apex, with the sutures all distinct, though the second and third do not have the apices of the tergites overlapping. Bristles long, the first visible one lacking apical.

central pair, the others all with apicals, the second and third usually with two unequal pairs of discals. Apex of fourth tergite with the usual apical backwardly projecting fringe of hairs and bristles.

Length, 7-8.5 mm.

Type locality, Christchurch. Other localities: Goulard Downs, 7.ii.22 (R. J. Tillyard); Ruapehu, 7.i.22 (Fenwick); Arthur's Pass, 6.i.23, 4,000 ft. (D. Miller); Day's Bay, 24.iii.22 (J. G. Myers); Cass, 1.xii.24, and Christchurch, 17.ii.22 (A. L. Tonnoir). The specimen in which the palpi are brownish yellow is a male from Kaituna, 19.ii.22 (A. L. Tonnoir).

***Calcager dubium*, n.sp.**

A female specimen which closely resembles *apertum* except in being smaller, more densely dusted on the head and thorax, with the dust more brownish, the palpi entirely orange-yellow, and the tibiae largely reddish-yellow. The basal two antennal segments are bright orange-red, and the wings are marked as in *apertum*.

The third antennal segment is narrower than in *apertum*, but this is a female character, and at least 1.5 times as long as the second; the parafacials have a series of unequal bristles, the longest being about as long as the arista and very much stronger than any of those in the specimens of *apertum* now before me. Each orbit is armed with three strong proclinate outer bristles.

The thorax has but three pairs of postsutural dorsocentrals, but is otherwise much as in the genotype.

Abdomen broader than in the male, more ovate and depressed, with the bristles shorter. The second tergite has two pairs and the third one pair of discals.

Wings much as in *apertum*, but the outer cross vein is nearer to the inner than to the angle of fourth. Neither of the two costal thorns is developed spine-like.

Length, 6.5 mm.

Holotype, Flora Camp, 3,000 ft., 5.i.30 (E. S. Gourlay).

***Calcageria incidens*, var. *nuda* nov.**

Several females that may belong to a distinct species are classed tentatively as a variety of *incidens* under the above name. They agree very closely with this species but lack the bristles on the upper surface of the first wing vein, which character I have accepted as of generic value.

There are no outstanding characters for their separation from *incidens* apart from this one and there being only females of both available it is impossible for me to make a hypopygial comparison to check my findings.

Length, 5-6 mm.

Holotype, and two paratypes, Otira, 9.ii.22, one, Kaikoura, 23.ii.22 (A. L. Tonnoir); one, Arthur's Pass, 23.xii.22, 3,500 ft. (J. G. Myers).

It may be deduced from the data presented above that generic limits in this family are rather uncertain. Undoubtedly if the characters utilized as generic criteria are variable or even subject to sexual dimorphism errors in placement will occur, and in determining specimens in the laboratory the taxonomist can go only as far as his available material permits, having no means of checking up his findings against field observations and particularly if he has no record of habits and no immature stage material to guide him. It is possible that there are two species in the collection which I now refer tentatively to as varieties of one, but there is no reason why I cannot treat them meanwhile as above.

Genus *CALOTACHINA*, novum.

This genus belongs to that group in which there are no fine hairs below the lower squama, the parafacials are strongly haired on their entire length, the arista has the second segment much elongated (Fig. 17), and the third segment of the antennae broad and much longer than the second. The first posterior cell of the wing is open and the fourth vein has a spur vein on its inner side between the angle and its apex. This last character may not be normal. The abdomen has well developed discal bristles. The sixth wing vein ceases at a short distance from the margin of the wing.

Genotype, the following species.

Calotachina tricolor, n.sp.

Male. Head with the ground colour entirely obscured by a dense coating of dust except on the interfrontalia and orbits, the former fuscous and slightly white dusted when seen from the side and in front, the frontal orbits pale brown to brassy dusted, with slight white reflections at various angles, face, lower half of parafacials and the genae white dusted, the occiput yellow dusted, less noticeably so centrally above. Antennae reddish orange, upper and lower edges and apex of third segment fuscous to black margined; aristae black; palpi orange-yellow. Lower and central hairs on occiput pale yellow, all the others and the bristles black. Eyes nude, hardly higher than the gena, the latter rather narrow. Frons at vertex fully half as wide as head and wider than its central length, much widened to anterior margin, the orbits at centre over half as wide as the interfrontalia, with numerous bristles and long hairs; interfrontalia with some hairs along each side. Profile as Figure 17.

Thorax brown, the pleura with yellowish grey dusting that almost obliterates the ground colour, humeri and lateral margins of mesonotum with a stripe of dense greyish white dust, disc of mesonotum fuscous, with an olivaceous tinge, showing indications of four vittae, the lateral edge of the outer one on each side and a spot in centre of hind margin rufous brown, the suture and some shadings on disc with whitish dust; scutellum rufous brown, dull. Dorsocentrals 2 + 4, acrostichals 2 + 3, the posterior presutural pair well in front of suture; prealar long; presutural intra-alar lacking, post-sutural pairs 3; pteropleural long and strong; scutellum with four pairs of laterals, the apical one cruciate and not much shorter than the next pair, the disc with one or two pairs of fine bristles and numerous hairs, none of them erect.

Legs tawny yellow, with paler dust. The bristling strong and similar to that of the genera already dealt with herein. The fore tibia with a series of bristles on the anterodorsal and another on the posterodorsal surface, the bristles becoming longer as they approach the apex. All tarsi at least as long as their tibiae.

Wings hyaline, veins yellow basally, becoming brown apically, all more or less suffused with yellow to dark brown, the inner cross vein with a spot-like brown mark, the outer one and the apical section of fourth beyond the curve with a pale brown margin. Costal thorn lacking, third vein with some fine bristles on node above and below; apical venation as Figure 18.

Abdomen brownish yellow, with a fuscous triangle on each side of the central line on second and third visible tergites, the central line reddish brown, the disc of first visible tergite almost entirely fuscous, the fourth with a fuscous mark in centre, all tergites reddish brown on each side at apex of the lateral curve and the second to fourth inclusive each with a conspicuous patch of greyish white dust on each side in front; the venter entirely yellowish grey dusted. First visible tergite with a pair of strong central apical bristles and on each side with some much weaker bristles that are rather far apart so that the apical series is not strikingly developed, second tergite with two pairs of discals and a complete apical series, third with a pair of central bristles in front and behind these a rather irregular transverse partial double series and a complete apical one, fourth tergite bristled from near base to apex, fifth with numerous shorter bristles. Third and fourth sternites each with numerous bristles apically, fifth with moderately long processes that are not abnormal in either armature or structure.

Length, 13 mm.

Holotype, Mt. Arthur, 2.iv.25 (A. Philpott).

Genus *MICROHYSTRICIA*, novum.

This genus is somewhat similar to the preceding one, but the parafacials are very strongly bristled and haired, the posterior pre-sutural intra-alar bristle is well developed, there are at least 4 sternopleural bristles, an additional weak one being present between the two strong upper bristles, and the first posterior cell of the wing has a long petiole, the general appearance of the venation being similar to that shown in Figure 3 except that the petiole is longer, almost entirely straight, the apical part of the fourth vein is less sloped outward at its anterior extremity, and the outer cross vein is less bent.

Microhystricia gourlayi, n.sp.

Head black, with light grey dusting, the interfrontalia more brownish than the frontal orbits; in greasy specimens the lower half of the occiput is brownish yellow as well as some part of the face. Basal two antennal segments reddish yellow, third segment and the aristae black, palpi brownish yellow. Profile of male as Figure 19. Frons even wider and shorter than in *Calotachina*, with the bristles and hairs stronger and longer, the parafacials with

numerous strong bristles and long setulose hairs; either orbit at widest point as wide as or a little wider than interfrontalia, the latter with a number of long incurved hairs along each side. Eyes with moderately long sparse hairs, less distinct in the female.

Thoracic bristles stronger and longer than in *Calotachina*, dorso-centrals 3 + 4, acrostichals 3 + 3, the posterior pair closer to the suture than in *Calotachina*, the posterior intra-alar in front of suture well developed; sternopleura with four or more bristles, the upper two strong bristles with a weak one between them and one or more usually distinguishable near the lower anterior bristle. Scutellum with 8 marginal bristles, the apical pair much weaker than the next one on each side and divergent, not cruciate, the discal hairs and bristles stronger than in the preceding genus.

Legs brownish yellow, very strongly bristled, the arrangement similar to that of *Calotachina*.

Abdomen concolorous with legs, the dorsum with a black central stripe that is widest at base, tapers apically, and in the male does not attain the apex. First visible tergite without the apical central pair of bristles, second and third each with about three pairs along the central line, between those on the third usually a number of much shorter erect bristles, the fourth with long bristles on entire dorsum that are longer at base, gradually becoming slightly shorter to apex, the lateral curve of all tergites with strong bristles. Third and fourth sternites each with a few long apical bristles, fifth with the processes neither abnormal in form nor armature.

Wings brownish hyaline, veins brown, yellowish at bases. Third vein with three or four bristles at extreme base, those above stronger than those below; sixth vein ceasing a short distance from the wing margin.

Length, 8-9 mm.

Holotype Male, and one male paratype, Balloon Hutt, 4,300 ft., 8.i.30 (E. S. Gourlay). Allotype and one male paratype, Mt. Peel, 26.ii.21 (A. Philpott).

I dedicate this species to the collector, who has taken some interesting species of this family now before me.

Genus HEXAMERA, Brauer and Bergenstamm.

1889. *Zweifl. K. K. Mus. Wien*, 4, 132.

This name must be used in place of *Protohystricia*, Malloch, which genus I erected for *Tachina signata*, Walker, unaware of the fact that Brauer and Bergenstamm had previously erected a genus for *Hystricia orientalis*, Schiner. The genus as previously stated in this series of papers is readily distinguished from any other met with in New Zealand by the presence of some setulose hairs on the hind side of the basal section of the stem vein of the wing. I have seen but two distinguishable species, the genotype and *huttoni*, Malloch.

Genus AVIBRISSINA, Malloch.

I describe below a new species of this genus, largely by comparisons with the genotype which it resembles closely in most characters including the colour.

Avibrissina laticornis, n.sp.

A larger and more robust species than *brevipalpis*, with the epistome more rounded and shining yellowish brown, and the disc of the scutellum largely of that colour. One of the most striking distinctions from the genotype lies in the different structure of the antennae. In *brevipalpis* the third segment is about 2.5 times as long as the second and about three times as long as wide; in *laticornis* the third segment is about 1.25 times as long as the second and not twice as long as wide, its width being but slightly less than that of the parafacial at centre. The palpi are also distinctly shorter. The post-sutural dorsocentrals in the type specimen are 4 in number instead of 3. The first and second visible abdominal tergites each have a complete transverse apical series of strong bristles, while in the genotype the first has sometimes a central pair separated by a wide space from the bristles at the lateral curves, and the second has always a central pair with the same separation from the lateral bristles. In *brevipalpis* the fifth abdominal sternite is large and has a slight but distinct emargination on the inner edge of each process near its apex, but in the new species though I have not dissected the type specimen the processes of the fifth sternite are slightly produced into a short rounded protuberance at their inner apical angle.

Length, 12 mm.

Holotype, Male, 11.ii.12, Old Man Range, No. 915 (Miller).

The presence of complete series of apical bristles on the first and second visible abdominal tergites is a rather exceptional character in the New Zealand species, but another genus described herein also has this character and is quite similar in some other features. It is extremely difficult to determine just what to use as generic criteria in the New Zealand representatives of the family and only intensive field investigations into the life-histories will eventually determine the exact relationships of the species.

Genus ENGYCERA, novum.

This genus is distinguished from any other known to me from New Zealand by the slender second antennal segment which is usually as long as or longer than the third segment, the latter being much wider and almost truncate at the apex. The frons of the male is not, or but little, wider than the third antennal segment in front of the ocelli, that of the female is over one-third of the head width, the male lacking, the female having proclinate outer orbitals. Eyes densely haired; parafacials with some sparse hairs to below middle. First posterior cell of the wing with a moderately long petiole, ending at least as far in front of wing tip as length of petiole; third wing vein with some very fine short hairs basally; sixth vein incomplete; outer cross vein much nearer to the angle of fourth than to the inner cross vein.

Genotype, *Engycera politiventris*, n.sp.

KEY TO THE SPECIES.

- | | |
|------------------|---|
| 1. Males | 2 |
| Females | 3 |
2. Abdomen entirely glossy black, without any trace of grey dust; small species, averaging 7 mm. in length; postsutural dorsocentrals always 3; second segment of arista hardly longer than thick, third segment swollen on not more than its basal third. .. *politiventris*, n.sp.
- Abdomen shining black, with quite dense grey dust, most distinct at bases of the tergites, the fourth visible tergite almost entirely dusted, when seen from in front against the light the dust apically brownish; larger species, averaging 11 mm. in length; postsutural dorsocentrals almost invariably 4, the second one from suture sometimes rather short and fine; second segment of arista about three times as long as thick, third segment swollen to the middle, there rather abruptly tapered and ending in a fine hair. .. *monticola*, n.sp.
3. Abdomen glossy black, almost without a trace of dust; postsutural dorsocentrals invariably 3. .. *politiventris*, n.sp.
- Abdomen shining black, very distinctly greyish white dusted at bases of the tergites; postsutural dorsocentrals 4 or 5. .. *monticola*, n.sp.

***Engycera politiventris*, n.sp.**

A deep black species, with silver grey dust on the head except the interfrontalia, whitish grey dust on the thorax, the mesonotum with four black vittae, abdomen glossy black, legs black, the tibiae more or less brownish yellow centrally, antennae black; palpi fuscous, sometimes yellowish basally; wings greyish hyaline, none of the veins distinctly clouded, the longitudinal veins yellowish basally; squamae white; halteres yellow.

Male. Head in profile as Figure 20. Frons not as wide in front of the ocelli as the third antennal segment; behind each eye and extending downward to middle of eye there is a series of exceptionally long erect fine bristly hairs, between each pair of which there is a much shorter hair. Third antennal segment a little shorter than second, slightly emarginate above near apex, the apical upper angle not very sharp. Hairs on parafacials carried to lower level of eyes and fine, those on the gena long and setulose though none of them bristle-like. Palpi long and but slightly dilated at apices, fine haired.

Thorax with the bristles well developed, the three pairs of postsutural dorsocentrals long and equal, the acrostichals 2 + 3; sternopleurals 3; one outstanding though not very long pteropleural; scutellum with three pairs of marginals, the apical one cruciate, the hairs on sides not carried to apex of venter.

Legs rather slender, the bristles strong, tarsi slender, the claws long, slender, and almost straight to apex. Fore tibia with several rather long anterodorsal bristles, the one nearest apex the longest; mid tibia with a strong ventral bristle; hind femur with long bristles on anteroventral and basal half of the posteroventral surface.

Wings normal, apical venation as Figure 21; a few very fine hairs on basal part of the third vein, confined to node below, but varying in extent above, though never extending to inner cross vein.

Abdomen narrowly ovate, the sutures all distinct. First visible tergite usually with a strong pair of apical central bristles, all the others with strong apical and discal bristles, strongest and most numerous on the fourth visible tergite. Fifth sternite with a pair of rather large rounded lobes that are usually pressed together and form a sort of keel, their surfaces with a few setulose hairs, but none along the margin.

Lower squama widened behind, the inner edge straight and lying against the margin of the scutellum, not bulged upward basally, the apex quite broadly rounded.

Female. Similar to the male in general characters, but the frons is nearly one-third of the head width at vertex, much widened to anterior margin, each orbit at middle is as wide as the interfrontalia and has at least two strong proclinate outer bristles.

The abdomen is wider, and the first visible tergite has rarely the apical central pair of bristles present.

Length, 6.5–7.5 mm.

Holotype, Male, allotype, and 4 paratypes. Purakanui, 1907 (D. Miller). Paratypes, Dun Mt., 2,000 ft., 15.iii.21 (A. Philpott); Barewood, 1908 (D. Miller); Tahunanui, 14.i.28 (E. S. Gourlay); and Roxburgh, 1909 (D. Miller).

***Engycera politiventris*, var. *setosa*, nov.**

This variety is identical with the typical form, but the third antennal segment of the male is broader, with a sharper upper apical angle, the parafacials are not as copiously haired nor do the hairs descend as far, and the genae have the hairs less numerous and amongst them there are a number of rather well-developed bristles.

Length, 6.5–7.5 mm.

Holotype, Male, and 3 paratype males, Mt. Grey, 20.ix.28 (E. S. Gourlay); allotype, Tahunanui, 10.iii.28 (E. S. Gourlay); paratypes, Aniseed Valley, 21.iii.22 (A. L. Tonnoir), Nelson, 28.ix.23 (A. L. Tonnoir), Dun Mt., 3,000 ft., 20.x.21 (A. Philpott), and two without data.

***Engycera monticola*, n.sp.**

A much larger and more robust species than the genotype, with the dusting more conspicuous, and present on the abdomen where the bases of the tergites are quite densely greyish white. The tibiae are usually reddish yellow, and the sides of the segments of the basal half of the abdomen are frequently quite noticeably red. This last character is rarely evident in the males of the genotype and when there is any red visible it is confined to the second visible tergite.

Male, Female. Structurally different from *politiventris*, besides the larger size, in having the frons in both sexes wider, the third antennal segment not over two-thirds as long as the second, the arista thicker, with the second segment longer, the parafacials haired only on upper half, and the postsutural dorsocentrals usually at least 4 in number. There is usually more than one pair of discal bristles on the second visible tergite. The general features of the fifth sternite are the same.

The wings are more yellowish basally, and the hairs on the third vein are always confined to the node both above and below.

Length, 11-12 mm.

Holotype Male and allotype, Mt. Grey, Canterbury, 15.iv.17 and 29.xii.16 respectively (Lindsay). Paratype males, Cass, 1.xii.24 (A. L. Tonnoir); Mt. Grey, Nov., 1917 (Lindsay); Obelisk, 10.iv.20 (D. Miller), and one without data from the last collection.

It would appear pertinent to note here that though this genus has the second antennal segment longer than the third that it is not at all closely related to the Tribe Tachinini, of which this has long been accepted as a character. The hind coxae in Tachinini are furnished with some hairs on their posterior margin above the bases of the hind femora, while in the above new genus there are no such hairs present. The European genus *Eriothrix* Meigen, has much in common with the new one, but in it the third antennal segment is distinctly longer than the second, and the parafacials are bare. The venation of *Eriothrix rufomaculatum* Degeer, is almost identical with that of *Engycera politiventris*.

***Engycera pallipes*, n.sp.**

I have one female in rather damaged condition that appears to be distinct from *monticola*.

It is of the same general size and habitus, but differs markedly in having the basal two segments of the antennae, the palpi, the legs, except a streak on upper surface of the fore femora basally, and the entire tarsi brownish yellow. The scutellum is also largely brownish yellow.

Structurally the two species are quite similar, but the third antennal segment is fully two-thirds as long as the second, the frons is distinctly narrower and the orbits less numerous bristled, with the series along the inner margin more differentiated. The fore tarsi are less widened, though it may be that this character will vary slightly in different specimens of the same species. The first posterior cell of the wing is closed at the margin and has no petiole, but again this character may be variable, though I hardly expect to the same extent as is shown in the type specimens of the two species under consideration. The abdomen has the first visible tergite shorter and without any apical central bristles, and the fourth instead of having a median and apical transverse series of bristles has the entire dorsum rather numerous bristled, with no definite central transverse series.

Length, 12.5 mm.

Holotype, Seaward Moss, 10.ii.10, no collector's name.

Genus PERRISSINA, novum.

A genus rather similar to the old concept *Exorista* of Europe, with the eyes densely haired in both sexes, the parafacials bare below the lowest frontal bristle and the frons much wider in the female than in the male, the former with, and the latter without, proclinate outer orbital bristles. It differs from typical species of the European group in having some fine short hairs below the lower squama, no hairs on the sides of the prosternum, the posterior presutural intra-

alar bristle lacking, and the frons of the female less than one-fourth of the head width at the vertex, widened to anterior margin. The ocellars are present in both sexes though much stronger in the female than in the male; the female has the uppermost bristle on each orbit slightly reclinate and divergent, and the male has no differentiated upper reclinate bristle, the inner margin of each orbit being furnished with a series of bristles that are strong at bases of the antennae and run into mere short fine hairs above, extending to near the anterior ocellus. The proboscis is short, the palpi are long, and the third antennal segment is at least twice as long as the second. Other cephalic characters may be seen in Figure 22, representing the head in profile. First posterior cell open, ending distinctly before wing tip, the outer cross vein much nearer to the bend of fourth than to the inner cross vein.

Genotype, *Perrissina crocea*, n.sp.

KEY TO THE SPECIES.

1. Face, at least on parafacials, the third antennal segment, palpi, and extreme apex of fourth visible abdominal tergite bright orange-yellow; abdomen dark metallic blue, undusted; claws of fore tarsi of the male densely covered on sides with microscopic pile which gives them a thickened appearance except their extreme tips, which are bare, the widest part just before the apical bare section, the claws of each pair equally formed; mid tibia of male without a ventral bristle. *crocea*, n.sp.
- Face dark, with whitish to brownish dust, most dense on the parafacials; palpi in males and third antennal segment largely or entirely fuscous; apex of fourth visible tergite not narrowly orange-yellow nor the general colour of the abdomen not dark metallic blue and undusted; outer claw of each fore pair in the male peculiarly twisted and enlarged near apex, the inner one normal, the hairing though dense not as evident as in *crocea*. 2
2. Parafacials densely greyish white dusted; abdomen of the male with the basal segments broadly semipellucid yellow on sides; squamae pale brownish yellow; scutellum partly brownish yellow; mid tibia of the male and female with a submedian ventral bristle; first visible tergite of male with a central apical pair of bristles, the second and third each with two or more pairs of discal as well as apical central bristles. *albiceps*, n.sp.
- Parafacials usually brown dusted except on upper third or less, the abdomen always much less extensively yellow on sides, and the squamae dark brown. 3
3. Abdomen bluish black, broadly ovate, when seen from behind against the light with distinct white dusting on bases of the tergites and a rather broad dark central vitta; parafacials velvety brown dusted, the paler changeable patch opposite the bases of the antennae merely yellowish, not white as in the other species; mid tibia of the male without a submedian ventral bristle; abdominal bristling of male as in *albiceps*; basal costal scale fuscous. *brunniceps*, n.sp.
- Abdomen shining bluish black, narrowly ovate, with hardly perceptible pale dust on the dorsum and usually distinctly reddish brown in part on the sides; parafacials either whitish dusted on almost their entire extent or with a distinct white patch opposite the base of antennae; mid tibia with a sub-median ventral bristle; basal costal scale yellow. 4

4. Narrowest part of frons about as wide as the third antennal segment; second visible tergite of the abdomen without discal bristles; parafacials white dusted, less distinctly below bases of antennae. *xanthopyga*, n.sp.
- Narrowest part of frons not as wide as third antennal segment; second visible tergite with a pair of distinct discal bristles; parafacials white dusted opposite base of antenna, brown dusted below. *variceps*, n.sp.

***Perrissina crocea*, n.sp.**

A metallic blue species, with the thorax greyish white dusted, the mesonotum with two submedian lines that are paler dusted than the remainder of the disc when seen from the side and undusted when seen from behind, the most conspicuous feature of the colouring consisting of the bright orange-yellow parafacials, third antennal segment, palpi, and basal scale of the wing. The two pairs of thoracic spiracles have their flaps rather duller orange-yellow, and the abdomen has no trace of dust, while the tip of the fourth visible tergite is orange-yellow.

Male. Head black, the face yellow, with rather dense yellowish grey dust, the parafacials orange-yellow, with rather slight whitish dust, variable according to the angle from which the head is viewed; antennae with the basal two segments brownish yellow, the third bright reddish orange; arista black; palpi orange-yellow; central occipital hairs yellowish white, the others and all the bristles black. Frons black, the orbits changeable grey dusted. Frons at narrowest point not as wide as third antennal segment, widened to anterior margin; profile as Figure 22a. Face slightly depressed, without a distinct central carina.

Thorax sometimes quite extensively brown on the pleura and always with a small amount of brown on the lateral margin of the mesonotum behind the wing bases; all hairs and bristles black. Dorso-centrals usually 3 + 4, acrostichals 2-3 + 3, prealar long, one or two long bristles on the pteropleura, sternopleurals 1-2 + 1; scutellum with 8 marginal bristles, the apical pair long.

Legs variable in colour, in mature specimens largely fuscous, in others mainly reddish brown. Fore femur with two dorsal and a posteroventral series of bristles and many long hairs on posterior surface; fore tibia with a series of fine short anterodorsal setulae and two posterior submedian bristles; outer claw of fore tarsus as Figure 22b. Mid tibia without a submedian ventral bristle, with one anterodorsal and four or more short posterior bristles; the claws similar to the fore pairs. Hind femur with long fine bristles on basal half of the posteroventral and all of the anteroventral surface; hind tibia with one anteroventral, two posterodorsal, and three anterodorsal bristles as well as some setulae between the latter.

Wings slightly smoky, especially costally, veins fuscous, base of costa and the basal scale bright orange-yellow. Extreme base of third vein with a few hairs.

Abdomen broadly ovate. First visible tergite deeply excavated in centre, with a pair of apical central bristles, second tergite with a pair of discal and a pair of apical central bristles, third with a

pair of discal and a complete apical series of bristles; fourth with numerous bristles on almost the entire disc. Fifth sternite with the processes orange-yellow and of moderate size, without any exceptional form or armature; superior hypopygial forceps with long rather densely haired backwardly projecting extensions.

Squamae dark brown. Knobs of halteres yellow.

Female. Similar in general colour and structure to the male, differing in having the frons at vertex a little less than one-fourth of the head width, widened to anterior margin, the orbits with two proclinate outer bristles and one reclinate and slightly backwardly-curved bristle at upper fifth, the hairs on the eyes not as long, the abdomen more broadly ovate and without apical central bristles on the first and second visible tergites and no discals on second and third. The mid tibia has the submedian ventral bristle present and the fore tarsi have the apical three segments slightly widened, and the claws small and equal.

Length, 10–12 mm.

A puparium mounted with the Male type specimen is shining chestnut-brown in colour, with the surface finely transversely striate, the metathoracic spiracular protuberances developed in the form of short horn-like projections much as we find in many Muscidae of the more typical genera, and the posterior spiracular discs small, in an apical depression (Fig. 23), with three straight slits.

Holotype, Male, Nelson, 3.x.28, mounted with puparium, but no data as to host (E. S. Gourlay). Allotype, Wanganui, 5.i.22 (J. G. Myers). Paratypes, York Bay, 4.ii.23 (J. G. Myers), and Ohakune, February, 1921, no collector's name.

Perrissina albiceps, n.sp.

Male. Head black, densely greyish white dusted, face testaceous, anterior part of gena in front of the haired part reddish brown, interfrontalia dark brown; antennae black, apex of second segment and extreme base on third reddish, palpi fuscous. Occipital hairs except those on margins yellow, the other hairs and bristles black. Narrowest part of frons not as wide as third antennal segment; profile as in *crocea*, but the third antennal segment is hardly twice as long as second.

Thorax black, with quite dense grey dust, the mesonotum with four black vittae, the central pair the narrower and ceasing at or shortly beyond the suture, the apex of the scutellum brownish yellow. Bristling as in *crocea*, but the lower anterior sternopleural bristle usually well developed.

Legs black, fore coxae partly and the tibiae largely brownish yellow, the tibiae with a dark stripe above and dark at bases below. Bristles as in *crocea*, except that the mid tibia has a rather long submedian ventral bristle. The outer claw of each fore tarsus is widened and peculiarly bent at the apex as if it had been pinched, the surface with dense pile except on the short black projecting tip; the inner claw apparently compressed on its entire length except near apex and not as noticeably pilose as in *crocea*.

Wings slightly brownish, most noticeably so basally, the veins dark brown, becoming paler basally, the basal scale fuscous, base of costa tawny yellow. Costal spine very small; node of third vein with a few fine hairs.

Abdomen broadly ovate, black, with the basal three tergites broadly brownish yellow and semipellucid on sides, the dark colour reduced to a dorsocentral vitta of variable width, the dusting distinct, white, most evident when the abdomen is viewed from behind against the light, most dense at bases of the tergites and more or less checkered beyond. Bristling as in *crocea*, but rather variable, the pair at apex of first tergite always distinct. The fifth sternite has the processes yellow and rather large, with their general form broad and apically rounded, without any hairs or bristles on the apical and lower portions. Backward extension of superior hypopygial forceps very short.

Squamae brownish yellow. Halteres yellow.

Female. Differs from the male in having the palpi tawny yellow, and the abdomen not yellow on the sides, the frons at vertex not one-fourth of the head width and with the bristling as noted in the generic description, the legs with the exception of the tarsi tawny yellow, and the abdomen with no apical bristles on the first tergite nor discs on the second and third. The tarsal claws are as usual very much smaller than in the male, and the fore pairs are symmetrical.

Length, 11-12 mm.

Holotype, Male, and allotype, Wairaurahira, 30.xii.16. Paratypes, Nelson, 6.xii.28 (E. S. Gourlay); Dun Mt.; Wellington; Salisbury's Opening; Stephen's Island; and two without data.

***Perrissina brunniceps*, n.sp.**

A blue-black species with a close superficial resemblance to some species of the genus *Calliphora*.

Male. Head black, epistome pale brown, frons without pale dusting, parafacials with brown dust which is changeable when viewed from different angles, the narrow postocular orbits similarly dusted, occiput and the raised and haired part of genae pale grey dusted; antennae and palpi black, the apex of second antennal segment slightly brownish; hairs on centre of occiput and the beard golden yellow, the other hairs and the bristles black. Eyes densely haired; general structure as in *albiceps*.

Thorax including the scutellum blue-black, with rather slight white dusting, the mesonotum with four dark vittae that are most distinct in front of suture when seen from behind against the light. Bristling as in *albiceps*, but there are only 2 sternopleurals in the type, and the hairs are longer.

Legs black, tibiae more or less brownish yellow centrally. Mid tibia without a submedian ventral bristle and the fine hairs decumbent and shorter than the more erect ventral hairs on the mid tibia in *crocea*. Fore tarsal claws as in *albiceps*. There are some distinctions in the armature of the mid metatarsus which I have not used in differentiating the species of the genus.

Wings slightly smoky, veins fuscous, not paler basally except the base of the costal vein which is yellowish brown, the basal scale fuscous.

Abdomen broadly ovate, tapered apically, with distinct white dusting which is most evident when seen from behind, and with a rather broad central undusted vitta. Bristling as in *albiceps*. Fifth sternite not much paler than the others, and the superior hypopygial forceps without a marked backward extension.

Squamae dark brown. Knobs of halteres brown, yellow at apices.

Length, 11 mm.

Holotype, Auckland, 9.x.27 (E. S. Gourlay).

***Perrissina variceps*, n.sp.**

This species is very similar in general colour and habitus to *brunniceps*, but the upper part of the parafacials opposite the base of the antennae is greyish dusted, the postocular orbits are pale grey and not brown dusted, the tibiae are paler and the mid pair have the submedian ventral bristle present, while the abdomen has the sides of the first and second visible tergites widely translucent brownish yellow. The wings are also more distinctly yellowish brown clouded along the veins basally, and the basal scale of the costa is pale brown.

Length, 11 mm.

Holotype, Male, no locality (D. Miller).

***Perrissina xanthopyga*, n.sp.**

Similar to *variceps*, but smaller and with a narrower abdomen. The parafacials are white dusted, less densely so below, the frons of the male is about as wide as the third antennal segment instead of much narrower than it, the legs are not at all noticeably paler on centre of the tibiae, the abdomen is less broadly yellow on the sides of the first and second visible tergites and the discal bristles are lacking on the second and third tergites. The wings are slightly smoky, with dark veins, the base of the costal vein is bright yellow, and the costal scale is orange-yellow.

Length, 10 mm.

Holotype without data from Dr. Miller's collection.

A second specimen differs from the type in having the tibiae and bases of the hind femora brownish yellow, but I can detect no other differences, though on the only mid tibia remaining on the specimen there is no submedian ventral bristle. Like the type there is no data on the specimen which is from the same collection.

Genus ASETULIA, novum.

I erect for the reception of a species without setulae or hairs below the lower squama and the general habitus of the *Peremptor* group this new genus, of which the following in addition to the lack of the infrasquamal hairs are the distinguishing characters:—Eyes long haired except on a narrow strip along the hind margin; parafacials coarsely haired on upper third, the hairs ceasing on a line with the apex of the second antennal segment, the width of the

parafacials subequal to the length of eye and almost as great as the height of the gena; frons in male one-third of the head width, with some proclinate outer orbital bristles; interfrontalia longitudinally furrowed, bare; face deeply sunken, bifoveolate, the central linear carina hidden when the antennae are in their normal position and in that case the large wide third antennal segment is only half visible in profile; second antennal segment not one-third as long as third; second segment of the arista hardly longer than thick; apical section of proboscis as long as lower margin of head; palpi longer than the third antennal segment; gena without a large raised haired part. Thorax with the bristling much as in *Peremptor*, but the scutellum has about 10 marginal bristles. Abdomen narrowly ovate, variably bristled, but the armature strong apically. The peculiar elongate backwardly directed numerous bristled paired processes of the hypopygium appear to be modified superior forceps, but I have not carefully dissected these organs so do not give a definite opinion. In any event, there are several New Zealand genera in which similar structures appear and I am not using this character as generic.

Genotype, the following species.

***Asetulia nigropolita*, n.sp.**

Male. Head black, face brownish, parafacials and genae reddish brown, more definitely red on posterior part of genae, the parafacials with dense brassy dust that is changeable according to the angle from which the head is viewed; basal two antennal segments red, third deep black; palpi fulvous yellow; central occipital hairs and beard orange-yellow, remainder of hairs and the bristles black. Profile as Figure 24. Frons at vertex about one-third of the head width, widened anteriorly; second antennal segment about one-fourth as long as third, the latter very wide.

Thorax shining black, with brownish grey dust, most distinct on mesonotum where there are about six brown or fuscous vittae that are evanescent posteriorly and variable in number and intensity according to the angle from which the surface is seen. Dorsocentrals 3 + 4, the acrostichals finer and about the same in number; prealar long; sternopleurals 2 + 1; pteropleura with one bristle a little longer than the others.

Legs black, knees narrowly red. Fore tibia with a few short anterodorsal setulae and two or three fine posterior bristles; mid tibia without a submedian ventral bristle, the ventral surface with the short hairs erect and more conspicuous than usual, the anterodorsal and posterior surfaces each with three or four bristles; hind tibia with one or two anteroventral and four or five anterodorsal and posterodorsal bristles. Claws of all tarsi moderately long and symmetrical.

Wings slightly brownish, more so costally, the veins dark brown, paler basally, basal scale brownish yellow. First posterior cell quite widely open, ending in front of wing tip; third vein with some minute basal hairs.

Abdomen glossy black, without dusting. First visible tergite without apical central bristles, second with a pair, but no discals,

third with or without a pair of discals and with a series of apical bristles; fourth with rather strong bristles on most of its surface. Hypopygium and fifth ventral segment in profile as Figure 25.

Squamae yellowish white. Knobs of halteres dark brown.

Length, 13-14 mm.

Holotype, Lake Moana, 16-21.xii.25 (A. L. Tonnoir). Paratypes, Blackball, xii.18 (J. W. Campbell), and Kumara, same collector.

A very distinct species which is well distinguished from all others known to me by the glossy black abdomen and the long somewhat clubbed and long-haired caudal appendages.

Genus *PROSENOSOMA*, novum.

A very striking member of the same group as *Erythronychia*, readily distinguished from any but the next genus dealt with herein by the remarkably long proboscis (Fig. 26), and from that genus by the small palpi. The hairs on the parafacials are very small and scattered, being difficult to detect below the level of the apex of the second antennal segment; the eyes are distinctly haired, the face is rather deeply bifoveolate, the vibrissae are well differentiated, and the second segment of the arista is about three times as long as thick. The other characters may be gleaned from the description of the genotype given below.

Prosenosoma greyi, n.sp.

Female. Head brownish yellow, covered with dense yellowish grey dust, the occiput, upper parafacials and frontal orbits fuscous; antennae black, second segment brown, base of third red, palpi testaceous yellow; central occipital hairs and beard pale yellow, other hairs and the bristles black. Profile as Figure 26. Frons at vertex over two-fifths of the head width; orbits with rather few bristles, about five incurved on the inner margin of each and one proclinate outer bristle near middle and two outwardly curved bristles above them; ocellars strong; outer verticals lacking or undifferentiated from the long setulose hairs on upper part of the occipital margin, the inner verticals long and strong.

Thorax black, densely grey dusted on pleura and lateral margins of the mesonotum, the disc of the mesonotum and the scutellum with brown dust, the former with four black vittae which do not attain the hind margin, the base and margin of the scutellum black. Dorso-centrals 3 + 3, acrostichals 2 + 2, posterior presutural intra-alar lacking as usual in the New Zealand members of the family. Sternopleurals 1 + 1, scutellum with six marginals and a pair of discal bristles, the discal hairs fine.

Legs black, densely grey dusted, all the tibiae brownish yellow. Fore tibia with an irregular anterodorsal series of bristles and two posterior bristles; fore tarsi slender and, like other pairs, longer than their tibiae.

Wings of moderate size, slightly smoky, the veins fuscous, some parts of them near the base yellow, the cross veins and the apical section of fourth vein narrowly brown margined. Seen from the

tip against the light there is visible a yellowish white streak across the wing at level of the apices of the anal and basal cells and the apical half of the subcostal cell is of the same colour.

Abdomen black, with densely silvery grey dusting which is checkered much as in most species of the genus *Sarcophaga*, Meigen. First visible tergite very shallowly impressed in front in centre, all tergites with apical central bristles, only the fourth with discals.

Squamae white. Halteres brownish yellow.

Length, 10.5 mm.

Holotype, Mt. Grey, 30.x.24 (S. Lindsay).

This species has much the appearance of a *Prosenia*, the general form of the head being similar, but that genus belongs to the Dexiini, having a plumose arista, and the face has a rounded central carina..

Genus XENORHYNCHIA, novum.

This genus is somewhat similar to the next preceding one, but the differences in the head structure (Fig. 27), especially in the lengths of the palpi readily distinguish them. The third antennal segment is about five times as long as the second in the male and about four times as long in the female, the second segment has almost invariably no outstanding bristle, but is densely short setulose, and the second segment of the arista is at least three times as long as thick. For other characters see the description of the genotype given below.

Xenorhynchia peeli, n.sp.

Male, Female. Shining black, with dense grey dust, the antennae and palpi black, second segment of former and base of third red, mesonotum with four partial black vittae, scutellum sometimes reddish brown at apex at least in the female, abdomen of male with or without a red spot on each side of second visible tergite, the dust in both sexes checkered on dorsum as in *Sarcophaga* species.

Male. Head in profile as Figure 27. Frons at vertex one-third of the head width, widened to anterior margin, the orbits narrow, with numerous fine incurved bristles along the inner margins, outer verticals undeveloped, inner pair long; ocellars quite long, the hairs descending very slightly below the lower frontal bristle and very short, not as long below as the hairs on the eyes. Face quite deeply bifoveolate, the carina linear and sharp.

Thorax with the bristling as in the next preceding species, but there are usually three well-developed sternopleurals.

Abdomen narrowly ovate, tapered to apex. First visible tergite with a pair of apical central bristles, second and third with a pair of discal bristles, second with a pair of apical central bristles that are more widely separated than the discal pair, third with a complete apical series, the central pair much more widely separated than the discal pair, fourth with several series of strong bristles on almost the entire surface. Processes of fifth sternite moderately long and wide, rounded at apices and not abnormally armed, and no outstanding bristles on any of the other sternites.

Female. Similar to the male, but the dusting denser. Frons with three outer bristles on each orbit above, the anterior one proclinate, the others usually outwardly curved. Abdomen more broadly ovate than in the male, the bristling somewhat similar, but less regular in arrangement in different specimens.

Fore tarsi not dilated, and the armature as in the next preceding species.

Costal thorn small but distinct, first posterior cell open, ending before the wing tip.

Length, 13–15 mm.

Holotype, Male, allotype and 3 paratypes, Mt. Peel, 5,300 ft., 15.ii.31, 7.i.30; paratypes, Mt. Arthur, 4,500 ft., 31.xii.28, Balloon Hut, 4,300 ft., 15.ii.31, Beeby's Knob, 27.i.29 (E. S. Gourlay); Dun Mt., 3,000 ft., 3.ii.21 (A. Philpott); Arthur's Pass, 3,000 ft., 29.xii.22, 3,500 ft., 26.xii.22 (J. G. Myers); and one without data in my collection.

Genus *PLETHOCHAETIGERA*, novum.

A peculiar genus which is readily distinguished from all those in which the frons is wide in both sexes and the eyes distinctly haired by the number of long strong bristles on the abdomen, and particularly by the presence of one or more pairs of strong bristles proximad of the apical central pair on the first visible tergite of the abdomen. I have placed in the genus species in which there are or are not distinct hairs on the parafacials below the level of the arisal insertion as it is sometimes rather difficult to determine whether these are present or not in some specimens, and occasionally in some there are one or two scattered minute hairs well below the majority of those that are readily detected with a good lens. I list as follows the other outstanding characters of the genus:—Face slightly bifoveolate, more noticeably so above; parafacial at middle not or very little over half as wide as eye; gena variable, less than or equal to half the eye height, the hairs carried forward to anterior level of eye; proboscis with the apical section not longer than height of head; palpi moderate; thorax with three or four pairs of postsutural dorsocentral bristles; abdomen strongly bristled, in the male usually with two or four bristles in front of the apical central pair on the first visible tergite, in the female with the anterior pair sometimes almost in line with the apical pair, discal bristles always present on the other tergites; fifth sternite with the processes moderately long, tapered to apices; first posterior cell of the wing open, ending distinctly in front of the wing tip.

Genotype, *Plethochaetigera fenwicki*, n.sp.

KEY TO THE SPECIES.

- | | | | | | | |
|-----------|----|----|----|----|----|---|
| 1. Males. | .. | .. | .. | .. | .. | 2 |
| Females. | .. | .. | .. | .. | .. | 3 |
2. Frons at vertex fully one-third of the head width; first visible abdominal tergite with a complete apical series of long strong bristles; parafacials with hairs descending very little below lower frontal bristles; fore tibia with five or six strong posterior bristles; fifth sternite of abdomen with the processes slender (Fig. 28), the preceding sternites quite fine haired. *fenwicki*, n.sp.

Frons not over one-fourth of the head width at vertex; first visible abdominal tergite with at most four, generally two, apical central bristles; parafacials with the hairs descending usually as far as lower level of the eyes; fore tibia with at most three, usually two, posterior bristles; fifth sternite of abdomen with the processes stouter (Fig. 29), the preceding sternites mostly strongly and rather densely bristled.

setiventris, n.sp.

3. Fore tibia with about six unequal posterior bristles; first visible abdominal tergite with a complete apical series of strong bristles; inner cross vein of the wing slightly proximad of middle of discal cell.

fenwicki, n.sp.

Fore tibia with two or three subequal posterior bristles; first visible abdominal tergite with at most four apical central bristles; inner cross vein of the wing slightly beyond middle of the discal cell.

setiventris, n.sp.

***Plethochaetigera fenwicki*, n.sp.**

Male, Female. A black species with dense grey dust on the head, thorax, and abdomen.

Male. Head black, the gena in front of and above the haired part brownish red, parafacials densely whitish grey dusted, the frontal orbits and postocular orbits a little less so, interfrontalia dull brownish black; antennae, palpi, and proboscis, black. All hairs and bristles, including those of the occiput and beard, black. Frons at vertex fully one-third of the head width, widened to anterior margin, the orbits narrow, with numerous long inner marginal incurved bristles on their entire extent and three or more outer bristles on the upper half or more, the anterior one or two proclinate and strong, the others outwardly curved and weaker; ocellar and inner vertical bristles long and strong, outer verticals shorter but well developed, the setulose hairs on upper half of the postocular orbits long and curved forward slightly at apices. Eyes long haired; gena about half as high as eye, with the hairs long and strong, carried forward to anterior level of eye on a grey dusted and slightly raised area that extends more than midway to eye from lower genal margin. Third antennal segment rather wide, hardly more than twice as long as broad, and about twice as long as second segment; arista with second segment fully twice as long as thick, third thickened on almost its basal half.

Thorax black, quite densely grey dusted on the pleura and lateral margins of the mesonotum, less densely so on disc of latter, where there are four rather wide black vittae that do not entirely attain the posterior margin, scutellum black at base, grey dusted at apex. Dorsocentrals 3 + 4, acrostichals variable but usually 2-3 + 3, prealar long, a strong bristle between the anterior presutural and posthumeral bristles; scutellum with 8 or 10 marginal bristles and the discal setulose hairs long and almost erect; sternopleura with at least three strong bristles and a number of setulose hairs.

Legs strong, and with numerous strong bristles, the anterodorsal and posterior surfaces of the fore tibia with six or more bristles, those on the latter irregular in length and arrangement.

Wings greyish hyaline, veins dark brown, hardly paler basally. Costal thorn undeveloped; inner cross vein slightly proximad of middle of the discal cell.

Abdomen coloured as thorax, but usually reddish brown on sides of the second and third tergites, the grey dust dense at bases of the tergites, fading out as it extends apically, the apices of the tergites black. First visible tergite with at least one pair of bristles anterior to the apical central pair and with the apical series entire; second tergite with the discals in two or more rather irregular series of four bristles, the apical series entire; third tergite with the apical half bristled, and four almost entirely bristled, though the armature apically is less strongly developed and more dense. Fifth sternite in profile as Figure 28, the two sternites proximad of it with fine erect hairs and no strong bristles, though the second sternite has a number of much longer bristly hairs.

Squamae white. Halteres brown.

Female. Similar to the male in general colour and structure, but the abdomen is nowhere reddish, and is more broadly ovate and less strongly bristled apically. The hairs descend more distinctly on the parafacials, and the fore tarsi are not distinctly dilated, though the fifth segment appears slightly so.

Length, 9–11 mm.

Holotype, Male, allotype, and 3 paratypes, Bold Peak, no date (Fenwick); one male paratype, 3.ii.12, Ranfurly, No. 917 (D. Miller).

***Plethochaetigera setiventris*, n.sp.**

Similar in general colouration and structure to *fenwicki*, differing markedly in the characters listed in the above key and in having the disc of the thorax with the vittae more nearly fused, throwing it into more marked contrast with the pale dusted lateral margins, the apex of the scutellum not grey dusted, the abdomen with the dust more checkered, and less noticeably dense at bases of the tergites and carried to their apices, and a brown suffusion along the entire centre of the disc. There is no trace of brown or red colour on the sides basally. The main structural distinctions are dealt with in the key, but in addition there are longer backwardly directed hypopygial processes in the male (Fig. 29) and there are fewer discal bristles on the second and third visible tergites, the latter being broadly lacking in bristles on each side of the disc.

Length, 10–12 mm.

Holotype, Male, Bold Peak (Fenwick); allotype, Mt. Arthur, 31.xii.28 (E. S. Gourlay); paratypes, Tararua, 20.xii.20, Cleughearn, 1.i.15, 3 without any data, and several Paradise, 1.i.20 (Fenwick).

There is a third species which I place tentatively in this genus. It differs from the other two in the lack of the central bristles proximad of the apicals on the first visible tergite, but the other characters are so suggestive of the genus that there can be no reason for its removal therefrom. I append the description.

***Plethochaetigera isolata*, n.sp.**

Similar to the other two species in general colour and markings, no red on the sides of the basal half of the abdomen, the mesonotum with the lateral margins broadly pale grey dusted, and the four black vittae showing signs of fusion much as in *setiventris*, the

abdomen almost as in that species, though the dust is paler, the apices of the segments darker, and the brown central suffusion not as noticeable. The epistome is more produced than in either of the other species, the entire parafacial is haired, the face is not evidently foveolate, and the frons of the male at vertex is over one-fourth of the head width. The principal distinctions between the species and the other two are to be found in the abdomen. The first visible abdominal tergite has no discal bristles in front of the entire apical series, the latter is quite strongly developed, the second tergite has one pair and the third three or four bristles in the discal series, while the fifth sternite is as shown in Figure 30, more triangular than in either of the other two, and the fourth sternite has a group of about four long erect bristles on each side near its apex. It may also be noted that the occipital hairs and the beard are yellow, and the fourth vein beyond the bend is more or less sinuate or arcuate, though in the direction of this there is considerable variation in the genus.

Length, 12-13 mm.

Holotype, Routeburn, 24.xii.13; paratype, No. 198f, no other data.

Female. One specimen in the collection belongs here. It may be known from the same sex in the other two species by the much dilated fore tarsi, which are very similar to those of *Veluta albicincta* (Fig. 42). The sides of the mesonotum are very conspicuously whitish grey dusted, and the abdomen has a complete apical series of strong erect bristles. The head is even more produced below than in the male. Second antennal segment almost as long as third.

Locality not given on label, which bears the number 268c (Coll. Miller).

The peculiar armature of the fourth sternite of the male and the prominent processes of the fifth sternite in the same sex ought to readily distinguish the species from its allies. The female has one discal bristle on the first tergite that is not present in the male, and both have the apical series complete.

Subgenus CHAETOPLETHA, novum.

I erect this subgenus for the reception of a species that has the first visible abdominal tergite with one or more pairs of bristles proximad of the apical central pair, no complete apical series, and the epistome not projecting as far as the vibrissal angles. In the three species placed in *Plethochaetigera* sen. str. the epistomal margin projects more or less markedly beyond the vibrissal angles upon which are the bristles. Lacking the male, I cannot give characters for that sex. The general build of the species is, as in the others, quite robust, the abdomen being broadly ovate. One character that may prove significant is the presence on the underside of the costa near its base of a single long forwardly directed bristle that extends to the humeral cross vein. I find this bristle also in *P. tonnoiri*, but in the other two species there are usually one or two additional bristles close to it. In the present species the basal segment of the arista is slightly longer than thick, and the second is about four

times as long as thick, the parafacials are haired to the lower level of the eyes, the hairs being well developed, and the palpi are rather short and thick. Other characters may be gleaned from the description of the type-species given below.

***Plethochaetigera (Chaetopletha) centralis*, n.sp.**

A black species, with dense grey dusting, more yellowish on pleura, the mesonotum and disc of scutellum broadly brown dusted centrally, the abdomen with similar brown dorsocentral broad stripe which is more or less spot-like and widest behind, the fourth visible tergite being almost entirely brown above.

Head black, densely grey dusted except on the interfrontalia which shows very slight dusting from certain angles, the dust becoming yellowish or brownish on the lower part of head. Antennae black, basal two segments brownish; palpi dark brown to fuscous. Frons at vertex almost half as wide as head, widened in front, the orbits less than half as wide as interfrontalia at middle; triangle grey dusted, extending but little beyond the anterior ocellus. Inner verticals strong, outer pair weak and short, inner marginal bristles on orbits long and fine, about 8 in number, the anterior one almost opposite base of second antennal segment, the proclinate outer bristles about 4 in number, fine, the hairs rather long. Parafacial at middle almost as wide as eye; face slightly receding below, the vibrissal angle with two almost equally long bristles, the other genal bristles very fine. Face not carinate, but with a rather deep central depression. Third antennal segment about four times as long as second, reaching well below middle of face, and rather slender, the arista inserted about as far from its base as length of second segment, the basal segment of arista fully as long as thick, second about four times as long as thick, the two combined not half as long as third, the latter thickened to near middle; palpi about as long as antenna and equal to apical section of proboscis, rather densely soft haired. Eyes haired.

Thorax black, dull, densely grey dusted, the mesonotum in addition to the central brown vitta with four rather faint partial dark grey vittae. All bristles fine and moderately long, the dorso-centrals 2 + 4; presutural lateral area with three bristles; prealar duplicated; presutural acrostichals 3; scutellars 6; sternopleurals 2 + 1.

Legs black. Bristles strong and about the same as in *tonnoiri*; fore tarsi not dilated.

Wings greyish hyaline, slightly brownish at bases; veins quite thick and dark; first posterior cell open, ending slightly in front of wing tip, fourth vein beyond bend longer than before it.

Abdomen coloured as thorax. First visible tergite hardly impressed centrally in front, with two or three pairs of bristles which are rather widely spaced from centre, and two or three bristles near lateral curve at apex; second with three or four pairs of bristles in centre, the one nearest apex not strictly apical, and a few lateral bristles; third with a pair of bristles near anterior margin from

which there extends on each side a series of bristles to about middle at the lateral curve, the sides rather numerous bristled; fourth, with numerous long hairs and bristles on entire surface.

Squamae white. Halteres brown.

Holotype female, Mt. Peel, 5,300 ft., 2.i.30 (E. S. Gourlay).

Genus CEROSOMYIA, Hutton.

I have already pointed out in this series of papers that this genus is the same as that identified as *Phorocera*, Robineau-Desvoidy, by Hutton in his work on the New Zealand Tachinidae.*

I have also stated that the New Zealand species depart from the typical forms so definitely that the name proposed by Hutton may be accepted as valid for the genus.

Having before me Hutton's type material, I give below my findings regarding the species names involved, in the hope that it may be possible for resident students the more readily to identify material in the genus.

Cerosomyia usitata, Hutton.

This species has the following characters which may be accepted as common to the whole of those referred to the genus herein: Frons of male narrower than that of female, but distinctly wider than the third antennal segment, with one strong upper reclinate orbital and no outer proclinate orbitals, the female with one or two strong outer proclinate orbitals and one upper reclinate bristle; eyes in both sexes distinctly haired; facial ridges with strong bristles ascending from vibrissae to well above middle (Fig. 31); parafacials bare; antennae inserted above middle of eye in profile, third segment usually over three times as long as second; second segment of the arista not or very little longer than thick; palpi well developed; proboscis short; gena never half as high as eye; parafacial in profile quite wide. Thorax with the bristles strong, the presutural posterior intra-alal always well developed. This last character segregates the following of the more typical Tachinidae of New Zealand from the rather aberrant and evidently endemic genera: *Arthuria*, *Genotrichia*, *Plagiomyia*, *Calcager*, *Calcageria*, *Uclesiella*, *Wattia*. All the genera in which the parafacials are very wide and the face bifoveolate, and even those that appear more nearly like some of the common Palearctic genera, such as *Perrissia*, have the bristle referred to lacking. The lack of this bristle has sometimes been cited as a character for the separation of Dexiini from Tachinini, but it is valueless for that purpose. In passing, it may be worth mention that in New Zealand there are no known representatives of Dexiini. An outstanding character of *Cerosomyia*, found also in *Phorocera* and a number of other genera, is the haired or setulose sides of the prosternal plate. In no other New Zealand genus are these hairs present. The armature of the dorsum of the abdomen is variable in the species, and even in individual specimens of the same species, the pair of apical central bristles on the first visible tergite being present or absent, but in

* *Rec. Cant. Mus.*, 3 (5), 325 (1930).

most cases distinguishable, while on the disc of the second tergite there are most frequently one or two pairs of discal bristles in the males, less frequently in the females; the third tergite has the discals more constant though not always present. The hind tibia has the anterodorsal surface with a rather regular series of short closely placed bristles with one or two longer bristles near the middle of the series. This character is met with in a number of Palearctic and Nearctic genera, but in no other New Zealand genus, all having the bristles either much fewer and more widely separated or much more irregular.

I have before me in addition to the type male of *usitata* males identified by Hutton as *oratus*, Walker, and *clathrata*, Nowicki. I have in the paper above referred to stated that I consider all the specimens, which are males, belong to the same species. In view of the fact that identifications of the older species are at best merely guesses, it is better to accept for the one now under discussion the name of the one represented by authenticated type material and to leave the decision of synonymy if any to subsequent investigators who may have access to the types of the other two species.

In his specific key* Hutton uses mainly colour as a guide to the separation of the species, running *oratus* and *clathrata* into the same couplet and separating them on the basis of the presence or lack of red spots on the abdomen. I find that the specimens before me both have such spots, as does also the type of *usitata*.

The head is fuscous behind, with greyish white dusting, the frontal orbits are fuscous, and similarly dusted, and the interfrontalia and remainder of head are reddish brown, paler below, with white dusting, the parafacials when viewed from above with the face towards the light has a reddish brown spot near the base of the antenna, the basal two segments of the antennae and the palpi are variable yellowish brown, and the third antennal segment and aristae black. Frons about one-third of the head width at vertex, widened to anterior margin in the male, the interfrontalia at middle about as wide as either orbit at the same point. Third antennal segment fully four times as long as the second and moderately wide; arista with the basal two-fifths swollen. Facial ridges with the bristles irregularly biseriate. In the female the frons is a little wider, the basal two segments and the base of third are paler, and the third is narrower, not as wide as the parafacial.

Thorax shining black, slightly bronzy, with whitish grey dust, the mesonotum with four narrow black vittae anteriorly; scutellum brownish yellow; pleura in the female sometimes rufous centrally.

Legs in male black, the coxae and femora more or less brownish shaded, the tibiae pale brown or yellowish brown; in female the coxae and femora are mainly yellowish brown and the tibiae are always of that colour.

Wings hyaline, veins brown, paler basally.

Abdomen black, with a more marked bronzy or greenish tinge than the thorax, the dust white and distinctly checkered, the sides

* *Trans. N.Z. Inst.*, 1904, 150.

of first and second visible tergites usually reddish brown. First visible tergite with the apical central bristles weak, second usually without the pair of discals, third usually with them present.

Squamae yellowish white, the inner edge of the lower one dark brown.

Length, 7-9 mm.

Localities: Christchurch, Nelson. Hutton gave Auckland and Ashburton as localities for *oratus*, and despite the fact that he gives no record of having seen the species, he states in the paper just referred to that the amount of red on the sides of the abdomen is variable, and it is difficult to determine to which of the two species some specimens should be referred. The identified specimen before me is from the Hutton collection and bears no locality label.

I might mention here that in addition to the generic characters listed the bristling of the fore tibia is characteristic, there being a partial series of short bristles on the anterodorsal surface, an almost complete series of similar bristles on the posterodorsal surface, and two or three much longer posterior bristles; the posterodorsal bristles are usually lacking in New Zealand genera of this family.

***Cerosomyia efferata*, Hutton.**

I am practically certain that this is another synonym of *usitata*, there being no tangible characters for the separation of the type female from those I am placing with that species. Despite Hutton's statement in his key that the tibiae and tarsi are black, his type specimen has the tibiae reddish brown and hardly darker than their femora. The only structural character that differs from the general run in *usitata* is the much stronger pair of discal bristles on the second and third visible tergites of the abdomen. The basal two segments of the antennae and the palpi are also darker, and the dust on the parafacials is greyish white, not noticeably yellow.

Christchurch.

I have two females and one male from Mt. Arthur that have the characters of the abdomen as in the above type and the second antennal segment and palpi black. They have the parafacials differently dusted also, the colour in the female being almost white, while in the male it is less conspicuous and pale greyish white below.

***Cerosomyia brouni*, Hutton.**

The type is a teneral specimen of some species that it will be impossible to identify because it must have been killed shortly after emergence from the puparium and neither the structures nor the colour are developed sufficiently to justify more than a guess at its specific identity. I believe, however, that it is one of the blue forms despite the present lack of that colour on the abdomen and without doubt it has been described under another name in the mature condition. The abdomen has the apical central bristles on the second to fourth tergites and the discals on the second and third well developed. The squamae appear to me to be brown.

Length, 4.5 mm.

Locality, Maketu.

***Cerosomyia fulvipes*, Hutton.**

Closely related to *usitata*, and separable from it merely by the paler colour of the legs and parafacials. I am very doubtful of the distinctness of these two forms, and it would be worth while for some local student of the family to attempt a check upon them by rearing them or by making extensive collections in the field so that dissections of the male hypopygia might be available for study.

In addition to the type female, I have seen specimens from Cass and Wanganui—in the latter one male.

***Cerosomyia recta*, Hutton.**

A much smaller species than *usitata*, with the abdomen black, checkered with greyish white dust, the antennae not very noticeably pale at base, palpi fuscous, squamae white, slightly yellowish along the inner edge of the lower one. In the type female before me the first posterior cell of the wing is closed slightly before the margin of the wing, all the abdominal tergites have a pair of strong apical central bristles, and the second and third visible tergites each a pair of strong discals.

Length, 7 mm.

Genus PROCISSIO, Hutton.

This genus is extremely close to *Peremptor*, Hutton, and because it may be confused with it I have decided to present a key in which I have included the species of both genera. It appears to me that the best character for the separation of the genera, if one desires to retain both, lies in the structure of the antennae. In *Procissio* the third segment is always slender, and, except in *milleri*, three or more times as long as second, and there is very slight sexual difference, while in *Peremptor* the third segment is much widened in the male, less so in the female, and in two of the species it is not much longer than the second.

Genotype, *Procissio cana*, Hutton.

KEY TO THE SPECIES.

1. Mesonotum with dense lavender grey dust, sometimes with a pinkish tinge, the central third with a complete velvety black vitta equal to the similarly coloured central third of the occiput; scutellum with dense grey dust centrally, broadly black on each side; wings seen from apex against the light white at bases, smoky apically, most noticeably so just beyond the white part, both cross veins and fourth vein on apical part more or less distinctly dark margined; first visible tergite with a pair of well developed erect apical central bristles; third antennal segment about twice as long as second; arista not longer than width of parafacial at centre; tibiae brownish yellow in both sexes. *milleri*, n.sp.
- Mesonotum and scutellum not as densely nor as pale dusted, the former without a broad deep black central vitta. 2

2. Third antennal segment hardly longer than second; first visible abdominal tergite with a pair of fine apical central bristles; fifth abdominal sternite of male with a rather deep excision near apex of each process on its underside, giving these the appearance of terminating in a short downwardly directed stout hook; head narrowed below in profile (Fig. 39), epistome appearing as if pushed inward and upward, not projecting, the proboscis short and enclosed in the mouth opening; vibrissae not well differentiated. . . .

Peremptor egmonti

Hutton

Third antennal segment much longer than second; first visible abdominal tergite without apical bristles except in abnormal specimens; fifth abdominal sternite of male not as above, without a downwardly directed hook-like apical process on each lateral arm, sometimes with a median or submedian excision; head not narrowed below in profile (Fig. 35), and differing in the characters listed above. . . .

3

3. Abdomen largely ferruginous yellow, with a dark dorsocentral vitta, and no apical central nor discal bristles on first and second visible tergites, nor discals on third; legs in both sexes tawny yellow, only the tarsi black. . . .

Peremptor kumarensis

Miller

Abdomen black, with grey dust, in one species more or less noticeably reddish on part of each side, second visible tergite with at least apical central bristles, and in the males usually with a pair of discal bristles; legs in males largely black, the tibiae sometimes brownish yellow. . . .

4

4. Third antennal segment not over 2.5 times as long as its greatest width, much larger and wider in the male than in the female, and deep black in both sexes, the apex broadly rounded, particularly in the male; fifth sternite in that sex with the processes simple, not excised in inner margin. . . .

Peremptor modica

Hutton

Third antennal segment slender, not less than three times as long as its greatest width, not noticeably larger and wider in the male than in the female, the apex narrowly rounded in both sexes. . . .

5

5. Males.
Females.

6

8

6. Width of frons at anterior ocellus distinctly less than half that of one eye seen from above; fifth visible tergite of abdomen with long bristly hairs on anterior or upper two-thirds and one or two transverse series of strong bristles near its apex; fifth sternite from below as Figure 32. . . .

albiceps, n.sp.

Width of frons at anterior ocellus about three-fourths that of one eye seen from above; fifth visible tergite with bristles on its entire surface, becoming stronger apically. . . .

7

7. Abdomen and legs entirely black; fifth abdominal sternite from below as Figure 34; abdomen over twice as long as wide; arista almost uniformly thick on basal three-fourths as in *modica* (Fig. 37). . . .

cana Hutton

Abdomen red on part of the sides; tibiae largely reddish yellow or brown; fifth abdominal sternite as Figure 36; abdomen less than twice as long as its greatest width; arista tapered from near base to near apex (Fig. 35). . . .

lateralis, n.sp.

8. Vibrissae inserted very close to the extremity of the raised vibrissal angle, distance from the bristle to the inner edge not one-fifth as great as the distance across the central flat area between the angles (Fig. 33a). 9
- Vibrissae inserted at some distance from the extremity of the raised vibrissal angle, length from inner angle to bristle about as great as distance across the central flat part between the angles (Fig. 33b). *cana* Hutton
9. Scutellum with six marginal bristles. *albiceps*, n.sp.
- Scutellum with eight marginal bristles. *lateralis*, n.sp.*

***Procissio milleri*, n.sp.**

A very pretty species, much like certain species of *Erythronychia*, and readily distinguished from any other in *Procissio* by the dense lavender grey dust on the head and thorax, the deep black or velvety blackish brown central stripe on the occiput which lines up with the complete similarly coloured central vitta on the mesonotum. The sides of the scutellum are of the same colour as the central vitta on the mesonotum.

Male, Female. Head fuscous in male, brown in female, becoming much paler below, the frons blackened above in male, the occiput with a broad central black stripe in that sex, and each parafacial with a transverse black stripe near base of the antenna that is variable in intensity and width according to the angle from which the head is viewed; in the female the dark parts are usually brown. Dust on frontal orbits, face, and genae denser in male than in female, and more silvery white. Basal two segments of antennae brown, base of third red, remainder of third and all of the arista black; palpi testaceous yellow to brownish yellow; proboscis shining black. Frons at vertex about two-thirds as wide as one eye, in female wider than eye, widened in front. Vertex with the inner pair of bristles long in both sexes, the ocellars well developed, the outer proclinate orbitals lacking in male, present in female; head much as in *lateralis* in profile (Fig. 35), but the third antennal segment is not three times as long as second, the arista is not longer than the third antennal segment, and more tapered on apical half.

Thorax black, or dark brown, the surface obscured by dense lavender grey dust that has sometimes a pinkish tinge, the dark central vitta sometimes narrowly pale brown on sides in the female. Usual bristling as follows: Dorsocentrals 3 + 3, acrostichals 1 + 1, prealar long, 2 lateral presuturals, 1 short pteropleural, 1 + 1 sternopleurals, 6 marginal scutellars and no discals.

Legs black in the male, the apices of coxae, sometimes the apices of the femora below, and the entire tibiae brownish yellow; in the female the coxae and femora are usually very little darker than the tibiae. Fore tarsi of the female not at all widened. Bristling as usual.

* This species is unknown to me in the female sex, and in placing it in the key I am making use of a structural character that distinguishes the male from that of the other two included above it, and which I have not found to vary sexually, so that it is extremely probable that my diagnosis will be found to be correct.

Abdomen in male dark brown, paler on sides and below, partly fuscous on dorsum and with checkered pale grey dust, usually with some brown dust along the centre of dorsum which is variable according to the angle from which it is seen; in the female the abdomen is usually reddish brown to fuscous, similarly marked to the male. First visible tergite with a pair of apical central bristles, second and third each with a discal and apical central pair, fourth in female with a transverse discal series of bristles, in male with an additional apical series; all tergites with one median and one or two apical bristles at the lateral curve. Fifth sternite of male much as in *albiceps*.

Wings normal, whitish at bases when seen from the apices against the light, the veins brown, both cross veins and apical section of fourth darker and with a narrow fuscous or dark brown suffusion. Outer cross vein more markedly bisinuate than in the other species, and the apical section of fourth vein much incurved just above the preapical angle.

Squamae yellowish white, margin yellow. Halteres yellow to brownish yellow.

Length, 7-8 mm.

Holotype, Male, and allotype, Mt. Arthur, 5,000 ft., 23.xii.21 (A. L. Tonnoir). Paratypes, Ohakune, 10.i.20 (D. Miller); Arthur's Pass, 3,500 ft., 23.xii.22 (J. G. Myers); Balloon Hut, 4,300 ft., 8.i.30 (E. S. Gourlay); Salisbury's Opening, 3,600 ft., 6.i.30 (E. S. Gourlay); Beeby's Knob, 26.xii.27 (E. S. Gourlay); Mt. Arthur, 4,500 ft., 21.xii.21 (A. L. Tonnoir).

This very pretty species is dedicated to Dr. D. Miller, who kindly placed in my hands most of the material upon which this report is based.

***Prociissio albiceps*, n.sp. (Fig. 33a).**

A rather aberrant species of the genus on account of the narrower frons than is usual in the males, but properly placed herein in my opinion. The general pale grey colour of the insect is an additional character for its recognition.

Male, Female. Head black, densely white dusted, the parafacials almost silvery, the area behind the vibrissae hardly showing any reddish below the dust; antennae black, second segment brownish; palpi fuscous, not noticeably paler basally; interfrontalia black, with a reddish tinge on part centrally in female. Frons of male at vertex less than half that of either eye seen from above, widened to anterior margin, the orbits linear above, widened in front, the armature as in *milleri*; in the female the frons at vertex is distinctly wider than either eye seen from above, the outer pair of verticals is minute, and each orbit has one to three proclinate outer upper bristles. The parafacial at centre is not as wide as the eye in the male, and wider than it is in the female. The eyes are distinctly haired in both sexes, a character common to the species of the genus. Palpi slightly clubbed in both sexes.

Thorax black, densely whitish grey dusted, the mesonotum with dull black vittae, the central pair narrower, beginning at anterior

margin, interrupted at suture and ceasing about midway from suture to hind margin, the sublateral pair represented by two elongate streaks, one before and the other behind the suture. Chaetotaxy as in *milleri*. Scutellum in both sexes with six marginal bristles.

Legs black. All tarsi slender and distinctly longer than their tibiae in both sexes, the bristles not very strong.

Wings greyish hyaline, showing white at bases as in *milleri*, the veins black and unmargined. First posterior cell narrowly open as a rule, sometimes closed in margin, the fourth vein beyond the preapical angle and the outer cross vein not as markedly bent as in *milleri*.

Abdomen coloured as the thorax, the dust distinctly checkered when seen from varied angles, and a slight brown dusted mark generally round the apical central pairs of bristles on the intermediate tergites in the male. First tergite usually unarmed at apex, second and third in male normally with a pair of apical central and a pair of discal bristles, and the fourth with a discal and apical series, the bristle at centre of lateral curve frequently lacking on the intermediate tergites; female always without apical centrals on first visible tergite and only rarely with any trace of discals on second. Fifth sternite of male as Figure 32.

Squamae white. Halteres yellow.

Length, 7–8 mm.

Holotype, Male, allotype, and one female paratype, Cass, ii.25 (A. L. Tonnoir). Paratypes, Ben Lomond, 14.ii.20 (Fenwick); Otira, 8.ii.22 (A. L. Tonnoir).

Procissio albiceps, var. *varians*, novum.

This variety is rather darker in general appearance, with a distinct brown mark on each side of the scutellum at its base in both sexes, the brown mark at apex of the intermediate abdominal tergites broader and more distinct, usually present in both sexes, and the upper extremities of the frontal orbits of the female brown.

In structure there are no tangible distinctions, though I have not dissected the hypopygia of the males. The fifth abdominal sternite is similar to that of the typical form in the male. The quite characteristic bristling of the fifth visible tergite of the abdomen of the male mentioned in the key to the species on a preceding page is the same as in the typical form. Palpi yellowish basally.

In two females before me there is a brown suffusion on the greater portion of the mesonotum which I do not regard as sufficient to justify varietal segregation.

Length, 7.5–9 mm.

Holotype, Male, allotype, and 2 paratypes, Salisbury's Opening, 4,000 ft., 16.ii.31 (E. S. Gourlay). Paratypes, Mt. Arthur, 3,000 ft., 2.i.29 (E. S. Gourlay); Ben Lomond (Fenwick); Nelson, 27.xii.21, a male with apical central bristles on the first visible tergite (R. J. Tillyard); Obelisk, 4.iv.20 (D. Miller); Ohakune, 20.xi.19; Maitai Valley, 16.iii.22 (A. L. Tonnoir); Upper Maitai, 26.xi.23 (E. S. Gourlay).

Procissio cana, Hutton.

I have before me the type-specimen of the genotype, which differs from the next preceding one herein in being darker grey dusted, in having the parafacials with a brownish tinge above, the strongest bristle on the vibrissal area much farther from the anterior edge of the raised part (Fig. 33b), the frons at anterior ocellus in the male about as wide as either eye, and the third antennal segment in that sex about four times as long as the second. In the female the third antennal segment is not over three times as long as the second. The underlying colour of the lower face and anterior parts of the genae are reddish brown, and the palpi are usually brownish yellow. There are usually two pairs of presutural acrostichal bristles on the mesonotum and a pair of discal bristles on the scutellum. Squamae white. Fifth sternite of male as Figure 34.

Length, 9–10 mm.

Type locality, Christchurch. Other localities: Cass, male and female; Upper Hororata, Nelson, Dunedin, Mt. Grey, Stephen's Island, Sunnyside.

Procissio cana, var. **valida**, Hutton.

Procissio valida Hutton, *Trans. N.Z. Inst.*, 1900, p. 55.

Procissio montana Hutton, *op. cit.*

I have before me the type-specimens of both the above and consider that they belong to the same species, and that it is in all probability merely a variety of *cana*. The specimens average larger and more robust and are darker in colour, with squamae brownish instead of white. Structurally they are similar, but it is not impossible that careful field work will prove that the two forms are entitled to separation as valid species.

There is no difference between the two type-specimens in the colour of the legs despite the key character given for their separation by Hutton in his paper.

Length, 11–13 mm.

Type localities, Taranaki and Mt. Peel. Other localities: Dunedin, Blackball, Nelson.

Procissio lateralis, n.sp. (Fig. 35).

A robust black species, with the sides of the abdomen more or less noticeably reddish, and the general build more robust than in the other species. The scutellum is also red in centre apically, and it has eight instead of six marginal bristles.

The head (Fig. 35) is much as in *cana*, though the frons of the male is not as wide, and the arista is more tapered on its apical half. The mesonotum is darker, and has four black vittae anteriorly and a fifth one in centre in front of the scutellum. There is frequently a bristle between the usual two on the presutural lateral area, and the sternopleural bristles are almost invariably 2 + 1.

Legs with the tibiae usually broadly reddish yellow centrally.

Fifth abdominal sternite of the male, as Figure 36, differing from that of any of the other species in having two short inner processes.

Squamae dirty white.

Length, 11–12 mm.

Holotype and two paratypes, Arthur's Pass, 2,500–2,700 ft., 25.xii.22 (J. G. Myers). Paratypes, Flora Camp, 3,000 ft., 16.ii.31 (E. S. Gourlay); Ben Lomond (Fenwick); and Otira. Female unknown to me.

Genus PEREMPTOR, Hutton.

I have already dealt with the three species of this genus known to me in this series of papers, and have merely to add the following synonymy:—

Procissio modica Hutton, *op. cit.*, p. 55 (male)*

Peremptor pavida Hutton, *op. cit.*, p. 56 (female).

I have before me the two type-specimens and have decided that the names apply to the sexes of the same species. Figure 37 shows the head of the male in profile, the third antennal segment in the female is much smaller and narrower.

The type localities are Wellington and Ashburton. I have additional specimens from Broad Bay, Ruapehu, and Peel Forest.

For other data I refer the reader to my previous paper.

Peremptor egmonti, Hutton.

The peculiar head of this species should insure its identification (Fig. 39).

Genus HETERIA, Malloch.

1930. *Rec. Cant. Mus.*, 3 (5), 324.

1931. *Pseudopeteina*, Townsend, *Rev. Ent.*, 1, 459.

1933. *Rhynchopeteina*, Ringdahl, *Skr. Svalb. Ishav.*, 53, 17.

I have carefully compared specimens of the genotypes of the New Zealand and North American genera and can find no reason to separate them. Both agree in having the basal and second arisal segments elongated, the basal as long as the second, and both combined from one-half as long as the third segment, the parafacials haired or setulose, and the infrasquamal hairs present. The other characters are almost identical, though the petiole of the first posterior cell is much longer in the North American species than in the New Zealand one. The parafacials in the former are more strongly armed, having rather well-developed bristles in a single series, but in some of the New Zealand species the armature is much more reduced than in *appendiculata*, there being only fine short hairs present. The first posterior cell of the wing is also in some species narrowly open instead of petiolate.

The genotype of *Petenia*, Brauer and Bergenstamm, lacks the infrasquamal hairs, and has the basal segment of the arista not longer than thick and much shorter than the second, both combined being not over one-fifth as long as the third segment. In other respects this also differs from *Heteria*.

This association of a Greenland species in the same genus with several from New Zealand is very remarkable, but on the basis of available generic characters it appears impossible to avoid the conclusion indicated by the synonymy cited above.

* Figure 38 should be referred to here.—D. M.

I have already presented a treatment of the species in the paper in which I described the genus and have nothing to add thereto at this time.

Genus OCCISOR, Hutton.

This genus contains robust blue-black species, all of which known to me are characterized by the bright orange-yellow flaps of the thoracic spiracular openings, and frequently the same coloured basal scale of the costa of the wing. The frons is about one-third of the head width in the male, a little wider in the female, and furnished with proclinate outer orbitals in both sexes; the parafacials are haired to, or almost to, the lower level of the eyes (Fig. 40), and the latter are quite densely haired. The mesonotum has four pairs of postsutural dorsocentrals, and in no specimen that I have seen are there any apical central bristles on the first visible tergite of the abdomen, though in one female there is one discal pair on the second, possibly an aberrant feature of this example. The outer cross vein in all specimens enters the fourth vein at not over one-fourth of the distance from its bend to the inner cross vein. The lower squama lies close against the side of the scutellum and is straight on its inner side, with a slight angle at its inner apex.

Genotype, *Occisor inscitus*, Hutton.

KEY TO THE SPECIES.

1. Squamæ white, edge of the lower one yellowish, that of the upper narrowly brownish; abdomen steel-blue, with faint white dusting at bases of the tergites; basal scale of the costa bright orange-yellow. *versutus* Hutton
- Squamæ fuscous or brown. 2
2. Upper squama paler than the lower, whitish, with dark brown edge; abdomen and basal scale of the costa as in *versutus*; lower squama of female narrowly white; fore tarsus in same sex but slightly widened, second segment not less than 2.5 times as long as wide, the basal one not dilated apically. *inscitus* Hutton
- Both squamæ dark brown, the edge of the lower one in female not paler than the remainder of its surface; fore tarsus very distinctly widened, the second segment not twice as long as wide and the first distinctly widened to apex from near middle; basal costal scale brown; abdomen glossy black, without a distinct blue tinge. *atratus*, n.sp.

Occisor inscitus, Hutton.

I have before me the type-specimen of this species, a male, and find that it is very similar to that of the next species, there being no distinction in the degree of hairiness of the eyes as stated by Hutton. I have used the only character in the above key that appears to me of value in the separation of the two species.

Type locality, Christchurch. I have females from Day's Bay (Myers) and Tauranga (E. S. Gourlay).

Occisor versutus, Hutton (Fig. 40).

In addition to the type male from Christchurch I have one from Wellington (Miller).

Occisor atratus, n.sp.

A larger and stouter species than the others, with the abdomen broadly ovate and glossy black, the squamæ dark brown, and the

basal scale of the costa brown except at its apex. The parafacials are wider than in the female of the genotype, the abdomen has a pair of discal bristles on the second and third visible tergites that are not present in either of the other species, and the bend of the fourth vein has a short spur vein. This last character is not dependable.

Length, 15 mm., width of abdomen at middle 7.5 mm.

Holotype, Dun Mt., 25.i.31 (E. S. Gourlay).

I may be in error in placing this species in this genus rather than in *Neotachina*, but lacking the male it is impossible to be absolutely certain of its exact generic position. In the only species that I place in the other genus of which I have females available the foretarsus in that sex is slender, while in both species of *Occisor* in which there are females in the collection here the fore tarsi are widened. This character is not a very good one on which to base generic limits, but it may suffice until further material in these two concepts is available.

Genus VELUTA, novum.

This genus is distinguished from its allies by the presence of one or more pairs of bristles proximad of the apical central pair on the first visible tergite of the abdomen and the very narrowly separated eyes of the male and the much-dilated fore tarsi of the female. In *Plethochaetigera* the eyes of the male are separated above at the narrowest point of the frons by not less than one-fifth of the head width, and in no species known to me except *isolata* are the fore tarsi of the female distinctly dilated. In *Veluta* the eyes are densely haired, and the parafacials are haired to the lower level of the eyes. The face is slightly convex, the epistome is distinctly produced, and the raised and haired part of the genae extends almost to the vibrissal angle.*

Genotype, the following new species:—

Veluta albicincta, n.sp.

A deep dull black species, with whitish grey dust on the head, thorax, and abdomen, on the latter forming three transverse bands, one at the base of second, to fourth tergites.

Male, Female. Head black, with dense white dust except on the interfrontalia and margin of upper occiput, the vibrissal angle brownish behind; antennae, palpi, and proboscis black. Frons in male narrower than third antennal segment for some length in front of the anterior ocellus, the interfrontalia not obliterated, in female at vertex slightly narrower than an eye, widened to anterior margin, either orbit at middle fully half as wide as the interfrontalia. Male with the inner verticals distinct, the outer pair not differentiated from the usual long erect fine hairs on margin of the upper occiput, the orbits with an inner marginal series of fine incurved hair-like bristles on their entire extent laterad of which there are numerous fine hairs, the lower bristle about level of base of antenna. Female

* It may be noted here that specimens with only two bristles at apex of the first visible tergite of the abdomen will run to *Zelandotachina*, but the only species of the latter that has the parafacials haired has the hypopygial backwardly directed pair of processes uniformly slender instead of dilated.

with the outer verticals about half as long as the inner pair; ocellars distinct, the orbits each with two or three outer proclinate bristles on upper half or less. Antennae moderate in length, third segment hardly longer than second. Profile as Figure 41.

Thorax black, with quite dense greyish white dust, most conspicuous on the lateral margins of the mesonotum anteriorly, the dorsal vittae four in number, black and not entire, least conspicuous in the male because of a fuscous or brown suffusion on the disc, the female sometimes with a brown suffusion between each pair of vittae but not in centre. Dorsocentrals usually 3 + 4; prealar distinct; sternopleurals 1 + 1; scutellum with six marginal and two discal bristles.

Legs black, the bristles less developed than in *Plethochaetigera*, the hind femur in male with a complete series of fine posteroventral bristles, and the fore tarsus of female as Figure 42.

Wings smoky, more so basally, the extreme base and alula white, veins black, inner cross vein slightly brown clouded. First posterior cell narrowly open.

Abdomen coloured as thorax, the white dusted band at base of the second visible tergite usually much narrower than the other two. First visible tergite with four or more central apical bristles, one pair behind the others, the apex, without a complete series; second with two or more discal pairs and a complete series of weaker bristles at apex in male, in female the apical series less conspicuous; third with more numerous discal and longer apical bristles in male, the discals in female usually four; fourth with the entire disc more or less bristled and haired. Hypopygium of male with a pair of long flat backwardly-directed long-haired processes that extend to apex, the apex of abdomen in profile as Figure 43. Fifth sternite of male in profile with two short basal processes, the apical pair somewhat triangular in profile as in the figure cited.

Squamae white, the lower one of the form typical in the New Zealand species of the family, lying close against the side of the scutellum and with a slight apical inner angle. Halteres yellow.

Length, 7.5–8.5 mm.

Holotype, Male, and allotype, Mt. Arthur, 4,500 and 5,000 ft., 21, 23.xii.21 (A. L. Tonnoir). Paratypes: Beeby's Knob, 26.xii.27 (E. S. Gourlay); Otira, 20.xi.19; Milford, 24.xii.20 (Fenwick); Arthur's Pass, 2,200 ft., 24.xii.22 (J. G. Myers).

Genus *ALTAIA*, novum.

This genus belongs to that group in which the parafacials are haired on the upper half or less, the eyes haired, and the abdomen with discal bristles on all but the first visible tergite. From most of the species of this group it may be distinguished by the fact that the parafacials at middle are narrower than the third antennal segment, and the arista is slightly elbowed at the junction of second and third segments, and from all known to me by the lack of the apical pair of scutellar bristles. These bristles are present in all other genera, though sometimes much shorter and weaker than the next pair, but in *Altaia* they are represented by at most a pair of

minute fine hairs. In some specimens there is a pair of short fine bristles near the apex on disc that may be mistaken for the apical bristles, but in all cases these are higher placed than the strong preapical lateral pair so that they cannot be mistaken for the apicals. For other characters see the description of the genotype given below.

***Altaia geniculata*, n.sp.**

Male, Female. A black, densely brownish grey dusted species, with the legs tawny yellow, the femora sometimes slightly darkened above at apices, and the tarsi black.

Head of male in profile as Figure 44, the frons of that sex about one-fourth of the head width at vertex, widened to anterior margin, the orbits at middle about half as wide as the interfrontalia, each with a long erect outwardly curved bristle near upper extremity and a series of incurved inner marginal bristles, and numerous fine hairs, the latter descending to about middle of parafacial. Female with the frons not wider at vertex than in male, more widened anteriorly with fewer fine hairs on the orbits and a proclinate outer orbital in front of the upper outwardly curved bristle. Antennae black; palpi sometimes yellowish at bases. Eyes short haired.

Thorax black, densely brownish grey dusted, mesonotum with 4 rather distinct black vittae that are interrupted at suture and discontinued about midway from there to hind margin. Dorsocentrals 3 + 3, presutural acrostichals usually 2, sternopleurals 2 + 1, the lower anterior one small.

Legs rather stout, the hind femora of male stouter than usual, the bristling not exceptional; fore tarsus of female not thickened.

Wings greyish hyaline, veins fuscous to black. First posterior cell open, ending very slightly before wing tip, outer cross vein less than one-third of the distance from angle of fourth to inner cross vein; costal thorn variable, but usually distinct.

Abdomen narrowly ovate in male, rather broadly ovate in female, the dust variable in tone, from brown to grey, and distinctly checkered. First to third visible tergites each with a pair of apical central bristles, second and third each with a pair of discal bristles, fourth with more numerous bristles. Fifth sternite in male with a short basal projection and a longer apical downwardly directed apical one when seen in profile (Fig. 45), the fifth visible tergite in that sex with only fine hairs on disc, no strong bristles present.

Squamae brownish in male, almost white in female, of the usual form. Halteres yellow.

Length, 6-7 mm.

Holotype, Male, Dun Mt., 2,000 ft., 15.i.28 (E. S. Gourlay). Allotype, topotypical, 25.i.31 (E. S. Gourlay). Paratypes, Mt. Duppa, 3,500 ft., 6.i.29, Upper Maitai, 13.ii.27 (E. S. Gourlay); Hilltop, 15.i.25, and Riwaka, i.23 (A. L. Tonnoir).

It may be noted here that the palpi show considerable variation in colour, in extremes being either black or tawny yellow, though sometimes they are tawny yellow with infuscated apices.

Here again we have a case of recurrent characters in the hypopygium of the male, there being the same elongated backwardly directed pair of haired processes as are found in *Asetulia* and several other genera including *Veluta*, and a considerable resemblance exists between the figures of *Veluta* and the present genus, facts that may indicate that the generic groupings adopted herein will prove to be merely tentative, based as they are upon external characters of possibly less fundamental importance than others not as yet exploited.

Genus PLATYTACHINA, novum.

I am placing in this genus a number of rather dissimilar species, all of them having one outstanding character in common—the well-exposed though reduced fifth visible abdominal tergite in the male. All are large robust species, with broadly ovate abdomen, four pairs of postsutural dorsocentrals, at least eight strong marginal bristles on the scutellum, and densely haired eyes. In all the females known to me the fore tarsi are distinctly widened. The rather similar appearing *Neotachina*, in addition to having the fifth tergite concealed or almost so, has but six outstanding marginal bristles on the scutellum and the females have the fore tarsi slender.

It is quite probable that my action in placing this rather diverse assemblage in the same genus will provoke dissent now or later, but I feel that the course adopted, though conservative, is the best under present circumstances, the preliminary segregation of related species and the identification of these being of prime importance to us rather than the making of an attempt to definitely limit generic concepts that without doubt will be subject to future modification with the accession of more detailed data, especially on life-histories and immature stage characters.

Genotype, *Platytachina major*, n.sp.

KEY TO THE SPECIES.

- | | |
|---|---|
| 1. Males | 2 |
| Females | 6 |
| 2. Frons at vertex almost as wide as either eye seen from above; abdomen brick-red, first visible tergite black, second and third each with a broad black central mark that is widened in front and behind, and the fourth with a small black mark in centre of anterior margin; first tergite without apical central, and second without discal, bristles. | |
| Frons at vertex distinctly narrower than either eye seen from above, or if about three-fourths as wide as eye then the abdomen is not coloured nor bristled as above. | 3 |
| 3. Antennae and palpi black; width of the frons at vertex about three-fourths as great as either eye seen from above; first visible abdominal tergite with a pair of fine apical central bristles, second with two pairs of similar discal and a complete series of apical bristles, the four at centre stronger than several on each side of them. | |
| Antennae partly, palpi entirely reddish to testaceous yellow; width of frons at vertex less than half that of either eye seen from above. | 4 |
- latifrons*, n.sp.
- atricornis*, n.sp.

- | | |
|--|-----------------------------|
| 4. First visible abdominal tergite with a pair of apical central bristles, second and third each with usually two pairs of discals and a pair of apical centrals, these bristles all strong and erect; length of species 13-15 mm. | <i>major</i> , n.sp. |
| First visible abdominal tergite at apex and disc of second with at most a pair of very fine bristles; length of species not over 13 mm. | 5 |
| 5. Narrowest part of frons wider than the third antennal segments. | <i>difficilis</i> , n.sp. |
| Narrowest part of frons distinctly less than as wide as third antennal segment. | <i>angustifrons</i> , n.sp. |
| 6. First visible abdominal tergite with apical central and second and third each with at least two pairs of discal bristles. | <i>major</i> , n.sp. |
| First visible abdominal tergite without apical central and second without discal bristles. | 7 |
| 7. Thorax and abdomen brick-red, both with the dorsum blackened centrally. | <i>latifrons</i> , n.sp. |
| Thorax and abdomen black, grey dusted, only the scutellum partly reddish. | 8 |
| 8. Legs with the exception of the tarsi tawny yellow. | <i>angustifrons</i> , n.sp. |
| Femora largely black, tibiae tawny yellow, tarsi black. | <i>difficilis</i> , n.sp. |

***Platytachina latifrons*, n.sp.**

This is the species identified by Hutton as *Tachina messor*, Walker, and which he considered a true *Nemoraea*. This is an error, the erect fine hairs on the upper surface of the lower squama which characterize that genus being absent in the New Zealand species. I cannot accept Hutton's identification as correct. Walker's description, while inadequate for present day requirements, is clear enough on certain points to prove that the species now under consideration is not the one he had. In fact, the paragraph by Hutton in which he says that "Walker's statement that the abdomen is narrow and nearly cylindrical must be a mistake" leads one to infer that he rather strained a point to make his species fit the description. The petiolate first posterior cell of the wing and some other characters of Walker's species lead me to believe that it will prove to belong somewhere near *Wattia*, though it is not possible without further data on the type-specimen to definitely place it in my present paper.

Male, Female. Head brownish yellow, upper half of occiput, the vertex and upper part of frons fuscous to black, interfrontalia red, the frontal orbits and upper part of the parafacials golden yellow dusted, slightly speckled and changeable in different lights, the remainder of the dusting in the face, genae, and lower occiput duller yellow, the central occipital hairs orange-yellow, the others and the bristles black; antennae orange-yellow, third segment usually blackened on margins and apex; aristae black; palpi orange-yellow. Profile as Figure 46; frons at vertex in both sexes almost as wide as one eye, much widened to anterior margin, orbits at middle wider than the interfrontalia, with the usual inner marginal incurved series of fine bristles, one outwardly curved bristle near upper extremity in both sexes, and in the female two or three upper outer proclinate bristles; the ocellars are long, proclinate, and divergent; eyes densely haired. Second segment of the arista almost twice as long as thick.

Thorax brick-red to fulvous yellow, dull, the mesonotum broadly black to dark brown on the disc, with greyish dust in perfect specimens, and but faint traces of four darker vittae, the scutellum and pleura usually entirely without black marks. Postsutural dorso-centrals 4; the presutural lateral area usually with three bristles, the prealar long, sometimes duplicated, presutural acrostichals two or three pairs, sternopleurals usually $2 + 1$; scutellum with at least 8 marginal bristles.

Legs coloured as thorax, the fore tarsi of the female browned to infuscated and distinctly widened from before apex of basal to apex of fourth segment, second segment a little over twice as long as its greatest width.

Wings greyish hyaline, more yellowish basally, veins orange-yellow at bases, merging into brown at apices. Inner cross vein at middle of discal cell, outer at less than one-third as far from pre-apical angle of fourth as from inner cross vein, bend of fourth narrowly rounded to subangulate, the vein just above the angle bent inward, outer cross vein sinuate, second section of costa over half as long as first, the first posterior cell open, ending distinctly in front of wing tip.

Abdomen coloured as thorax, first visible tergite almost entirely black above, second and third each with a broad central black mark which is widened in front and behind, fourth with a central anterior marginal black mark. In fresh and un rubbed specimens there is a brownish grey dust on the surface that almost obliterates the markings, but ordinarily the latter are conspicuous. Apex of male abdomen seen from the side as in Figure 47. General form broadly ovate, bristled as noted in key.

Squamae white, margins yellowish. Halteres yellowish brown. Length, 12-14 mm.

Holotype, Male, and allotype, Eglinton, 31.xii.20 (Fenwick). Paratypes, Lake Peel, 28.ii.21, Mt. Cook, 4.i.29, Mt. Arthur, 4,500 ft., 2.ii.23 (A. Philpott); Mt. Cleughearn, 25.i.17.

***Platytachina atricornis*, n.sp.**

A much darker species than *latifrons*, only the apical portion of the scutellum and the sides of the first three visible abdominal tergites distinctly brownish red, the ground colour of the head brown, showing but faintly through the dense grey dust on the lower anterior part, the antennae, frons, and palpi black, and the legs of the same colour, only the tibiae centrally reddish brown.

Head in profile much as in *latifrons*, but the epistome more produced, the frons narrower, at vertex hardly over two-thirds as wide as either eye, the antennae as Figure 48; and the palpi much shorter.

Thorax dull black, the lateral margins of the mesonotum with rather distinct pale grey dust, the disc with four partial, more intensely black, vittae, apical half or more of the scutellum brownish red. Bristling similar to that of *latifrons*.

Wings greyish hyaline, veins brownish basally, becoming black apically. In arrangement of veins similar to *latifrons*, and with the same series of four or five setulae at base of third vein above and below.

Abdomen coloured as thorax, the sides of the first three tergites rather broadly but inconspicuously brownish red, the surface with rather dense grey dust on second to fourth tergites except on apices and a narrow central vitta which are black. General form not as broadly ovate as in *latifrons*, nor as noticeably flat on dorsum, with fine apical central pair of bristles on first visible tergites and one or two similar pairs of discals on second, the latter with four long erect apical central bristles, third tergite with one or two pairs of long discal and a series of long apical bristles that are more conspicuous and stronger than in *latifrons*, fourth with similarly long bristles on most of its surface; apex of abdomen much as in the preceding species, but the hypopygium is very different, the superior pair of forceps being bent up at apices, and the inferior pair having no group of stiff bristles near base on the inner edge (Fig. 49).

Squamae white, edge of lower one slightly yellowish.

Length, 12 mm.

Holotype, Male, Ben Lomond, 14.ii.20 (Fenwick).

***Platytachina major*, n.sp.**

This species averages larger than any of the others; sometimes specimens attain a length of 15 mm., and in both sexes there is a character that appears to separate it from all its congeners. This consists of a series of widely spaced short spines on the costal vein between humeral vein and the apex of the subcosta that are situated on the upper surface between the usual upper marginal closely placed series and the membrane (Fig. 50). In the other species there are no stout spines, the armature consisting of a more closely placed series of microscopic fine hairs.

Male, Female. Head fuscous, showing brown below the dust on lower anterior part and face, in the male with dense grey dust, in female brownish dusted, the dust least evident on face; interfrontalia undusted when seen from the side, slightly dusted when seen from in front; antennae black, second segment on inner side and apically, and third at base, reddish yellow; palpi reddish yellow. Male with the frons at vertex about one-third as wide as either eye seen from above, widened to anterior margin, the orbits narrow above, widened below like the interfrontalia; vertex with the inner pair of bristles moderately distinct as long as the ocellars, each orbit with a series of inner marginal incurved fine bristles that are very short above and become longer below, laterad of these many rather long fine hairs and below a few bristles, the lower bristle almost opposite middle of second antennal segment and nearer inner than outer margin, the parafacials haired to lower level of eye, the appearance somewhat speckled above. Frons of female at vertex almost as wide as either eye, the orbits widened in front, but the interfrontalia parallel-sided; vertex with all four bristles distinct but not very conspicuous; each orbit with the usual inner marginal series of

incurved bristles, which are quite regular and stronger than in the male, the upper half with two proclinate bristles and above these one outwardly curved bristle, none of which are present in the male, the lateral hairs less numerous and shorter than in the male and not descending as far on parafacials. Face not bifoveolate, almost flat, slightly depressed above vibrissae in profile. Vibrissae about as far above epistome as length of second antennal segment, with a number of moderately long bristles adjacent to them, some of which are above them, but the highest is well below middle of facial ridges and much finer than the lower bristles. Antennae extending to slightly below middle of face, inserted about middle of eye in profile, third segment about 1.75 times as long as second, rounded at apex; arista swollen at base, tapered to middle of third segment, the second segment about as long as thick. Gena about half as high as eye, the haired and slightly raised part extending to level of anterior edge of eye; the eyes distinctly haired; palpi slender, of moderate length; proboscis short. Thorax brownish black, slightly shiny, with rather dense dust, most distinct on the lateral margins, and especially the humeri; in the male the dust is pale grey except on the disc of the mesonotum, where it is brownish, and in the female it is almost all brownish; the mesonotum with four black vittae that do not extend to the posterior margin; scutellum broadly brownish yellow apically. Dorsocentrals rather variable, $2-3 + 4-5$, at least two pairs of presutural acrostichals, the other bristles also variable and fine, but in no case is the posterior presutural intra-alar present; sternopleurals $1 + 1$; pteropleura with two or three fine bristles amongst the finer hairs; scutellum with at least 8 fine marginal bristles.

Legs brownish yellow, shaded with black or fuscous on part of the femora, and especially the fore pair in the male. Fore tibiae in the female sometimes with the posterodorsal surface weakly bristled as well as the two stronger bristles on the posterior surface; fore tarsus in same sex distinctly widened.

Wings greyish hyaline, slightly pale brown at bases, veins yellowish brown at bases, darker at apices. Venation as in *latifrons*.

Abdomen brownish yellow, the disc broadly, sometimes almost entirely, black, and with grey dust, the sternites black. Both sexes with the general form broadly ovate and slightly flattened on dorsum, the bristles erect and rather strong, consisting of one apical central and sometimes an anterior pair on first visible tergite, an apical central and two or three discal pairs on second tergite, an almost complete apical series and several pairs of discals on third, and scattered bristles on fourth. A remarkable feature of the male type is that the right side of the fourth tergite is strongly bristled, and the left side has merely long setulose hairs. In one paratype male the abdomen is entirely normal, but in another there is again an asymmetrical feature of the fourth tergite, but here it has apparently been injured, as it is shorter and unarmed on the left side. There are other cases of the same nature in the collection that are listed in this paper.

Squamae white, margins yellowish. Halteres yellowish brown.
Length, 13–17 mm.

Holotype, Male, Hunter Mts., 4,000 ft., 5.i.23. Allotype, Mt. Arthur, 4,500 ft., 2.ii.23 (A. Philpott). Paratypes, Male, Beeby's Knob, 26.xii.27 (E. S. Gourlay); Female, Gordon's Pyramid, January 24 (A. Philpott); one damaged Male, Mt. Arthur, January 24 (A. Philpott).

One of the largest species in the collection, readily distinguished from the other large forms by the base of the stem vein, flat face, and other characters.

***Platytachina difficilis*, n.sp.**

A considerably smaller species than *major*, differing in the narrower frons of the male, the lack of bristles on the first visible tergite and disc of second, and the generally black femora.

Male. Head brownish red, infuscated on frons and upper half or less of the parafacials, and the occiput, the raised part of genae not as dark but grey dusted, the other dark parts also grey to brownish grey dusted, antennae with the basal two segments and the narrow base of third of the same colour as the pale parts of the head, the remainder of third segment and the aristae black; palpi reddish yellow. Frons at vertex fully as wide as third antennal segment and about one-fifth as wide as one eye seen from above; vertex with numerous long setulose hairs but no well developed bristles; ocellars generally quite distinct, the orbits with numerous fine inner marginal incurved bristles that become longer anteriorly, and laterad of these numerous much shorter finer hairs that descend to or below level of middle of third antennal segment, the parafacial comparatively wider than in *major*, the epistome more produced, and the third antennal segment less than 1.5 times as long as second. The aristae are swollen on less than their basal halves.

Thorax black, slightly shiny, with grey dust, and four black vittae on the mesonotum that are not continued to posterior margin; scutellum broadly reddish brown at apex. Armature as in *major*, but the lower anterior sternopleural bristle is usually present.

Legs black, coxae behind, apices of femora ventrally, and all of tibiae brownish yellow.

Abdomen black, with grey dust that is slightly checkered, the lateral curves of tergites more or less broadly brick-red to brownish yellow. First visible tergite without central bristles, second without discals but with two to four apical central bristles; third with at least one pair of discals and a complete series at apex; fourth with scattered bristles on almost the entire surface; fifth with rather closely placed and moderately strong bristles; sixth fine haired except at apex, where there are a few fine bristles in a transverse series. Hypopygium seen from the side as Figure 52.

Squamae tinged with brownish, margins yellow. Halteres brownish yellow. Costal vein of wing as in Fig. 51.

Length, 11–12 mm.

Holotype, Beeby's Knob, 4,700 ft., 27.i.29 (E. S. Gourlay). Paratypes, Mt. Peel, 5,300 ft., 12.ii.31 (E. S. Gourlay); Blackball, March 20 (J. W. Campbell).

I have before me a female that I tentatively place with this species. It is similar in general colour and appearance to the male, but the abdomen is entirely black, with checkered grey dust which is not what one would be led to expect from the general rule in related species. The dust on the head is quite dense and brownish yellow, the basal two antennal segments are fulvous yellow and the third black.

The fore tarsi are not as much widened as in *major*, the first visible tergite and the disc of third are unarmed, the apex of second has a pair of strong bristles in centre and the third has a complete apical series; the fourth has the apical half bristled, with the apex compressed from the sides so that the apical opening appears slit-like.

Length, 12 mm.

Locality, Waiho, 20.i.22 (A. L. Tonnoir).

***Platytachina angustifrons*, n.sp.**

This species is very similar to *difficilis*, differing essentially in having the frons of the male reduced to a mere line at its narrowest point, where it is not as wide as the third antennal segment. Both species have the fifth abdominal sternite of the male with a pair of short central lobes much as in *Procissio lateralis*, the ventral view of the right half being as Figure 53. The hypopygium is very similar to that of *difficilis*, but the inferior forceps are not as wide and are less curved, with sharper apices.

Length, 11-12 mm.

Holotype, Male, Mt. Rolleston, 15.xii.20 (E. H. A.). Paratypes, No. 122c (Miller); and Arthur's Pass, 3,500 ft., 23.xii.22 (J. G. Myers).

Two specimens that I take to be females of this species differ from the male in having the legs with the exception of the tarsi fulvous yellow, the abdomen entirely black, with slightly checkered grey dusting, and the wings more yellowish basally.

The abdomen has a pair of apical central bristles on the second visible tergite and usually small discals on the third. The fore tarsi are more distinctly widened than in *difficilis*, more like those of *latifrons*, and the third antennal segment is about 1.25 as long as the second.

Localities, Otira, 8.ii.22 (A. L. Tonnoir); No. 133b (Miller).

Genus PHAONIELLA, novum.

This genus differs from the preceding one in being more slender, in having 6 well developed scutellar bristles, and the fifth abdominal sternite not exposed. The face is also slightly bifoveolate and the postsutural dorsocentrals are three in number.

Genotype, the following new species.

***Phaoniella bifida*, n.sp.**

An entirely black species, with black antennae and palpi, the thorax slightly shining and with grey dust, the mesonotum with four black vittae, but the space between the submedian pair almost as dark as the vittae, so that there appear to be but three broad black vittae. Abdomen with distinct grey dust, the dorsum with black apices to the tergites and with a central black vitta. Wings greyish hyaline, alar lobe white, veins yellow basally, dark apically.

Male, Female. Head with silvery grey dusting on the parafacials below bases of the antennae in male, the frontal orbits and parafacials in female more yellowish grey dusted; the ground colour of the vibrissal angle showing reddish brown. Frons of male in front of ocelli reduced to a mere line, much narrower than the third antennal segment, with fine closely placed bristles on the entire extent of the inner edges of the orbits; ocellars weak but evident. Female with the frons at vertex about one-third of the head width, widened to anterior margin, the orbits narrow above, widened in front, the interfrontalia slightly widened in front, each orbit with the usual inner marginal series of bristles and an upper outwardly curved and three proclinate bristles on upper half. Eyes distinctly haired.

Thorax with 3 + 3 dorsocentrals, one prealar, the hairs rather long, sternopleurals 2 + 1.

Legs black. Fore tarsi of female not at all widened, all tarsi longer than their tibiae.

Wings hyaline. Third vein with a few basal setulae, first posterior cell variable at apex, either narrowly open or closed, rarely with a minute petiole.

Abdomen narrowly ovate, the first visible tergite in male with a pair of central apical bristles and sometimes a weaker pair anterior to them; second with a pair or two of discals in the male, usually none in the female, and two to four central apicals; the third with two or more pairs of discals and an apical series. Apex of abdomen with the fifth sternite largely exposed in profile and with a deep rounded excision in each lateral lobe near centre; fourth sternite with four or more strong, straight, downwardly directed bristles.

Squamae white, margins narrowly yellowish. Halteres yellow. Length, 8.5–10 mm.

Holotype, Male, allotype, and 2 paratypes, Mt. Arthur, 4,000 ft., 31.xii.28 (E. S. Gourlay). Paratypes, Salisbury's Opening, Mt. Arthur Table Land, 4,000 ft., 15.ii.31, 3,600 ft., 6.i.30 (E. S. Gourlay); Lake Peel, 25.ii.21; Mt. Arthur, 26.ii.21 (A. Philpott); Mt. Peel, 5,300 ft., 7.i.30 (E. S. Gourlay).

Genus NEOTRYPHERA, novum.

This genus is erected for the reception of a small black species which has in common with the next one dealt with the lower squama narrowly rounded on its apical margin, the inner edge more rounded than the outer, without an inner apical angle, and lying well clear of the lateral edge of the scutellum. In all the other New Zealand genera the lower squama is much wider, with a more or less developed

apical inner angle, and lies close against the lateral edge of the scutellum, most frequently touching it on the straight part of its inner edge. The eyes are not noticeably haired unless when seen under a magnification of at least 34, and then there are hardly visible minute widely scattered hairs. Frons in both sexes about one-third of the head width, with the usual inner marginal series of incurved bristles on each orbit which number usually four and are strong, the lower part of the series divergent and more closely placed, usually three in number, of which the anterior one is slightly below the antennal base, and three upper outer bristles, the two anterior outwardly and forwardly directed, the upper one outwardly curved; all four verticals present, the inner pair the longer, and the ocellars well developed. Parafacial in profile rather wide above, narrowed below, above vibrissae almost linear; vibrissae strong, a few setulae above them; gena not over one-fourth of the eye height, haired to almost anterior level of eye; face not carinate, slightly depressed; antennae normal, third segment about 1.5 as long as second; arista swollen on basal fifth or less, second segment about as long as thick; proboscis and palpi normal. Thorax with prosternum and centre of propleura bare; postsutural dorsocentrals 3, the presutural posterior intra-alar lacking; scutellum with but 4 marginal and no discal bristles; sternopleurals 1 + 1; postscutellum not large, falling well short of apex of scutellum. First posterior cell of wing closed, ending almost in wing tip; costa with some distinct bristles; outer cross vein about midway between inner cross vein and bend of fourth, the latter subangulate; third vein setulose at base. Abdomen with apical bristles on all segments and discs on all but first visible tergite.

Genotype, the following species.

***Neotryphera atra*, n.sp.**

Male, Female. Head black, interfrontalia dull brownish black, orbits glossy, face with greyish dust; apex of second antennal segment brownish red; palpi rufous yellow. Profile as Figure 54.

Thorax glossy black, humeral angles grey dusted, the pleura slightly so. Dorsocentrals 2 + 3, acrostichals 2 + 1-2, notopleural bristles subequal in length, prealar moderately long. In one male specimen there is an extra bristle on one side between the usual lateral and apical bristles.

Legs black, stout, the fore tibia with four or five irregular antero-dorsal and two posterior bristles; mid tibia with the submedian ventral bristle long; hind tibia with 2 to 4 unequal posterodorsal and anterodorsal, and usually two anteroventral bristles; fore tarsi of female very slightly thickened apically.

Wings slightly smoky, veins brown anteriorly, yellowish basally and posteriorly. Costal vein with some irregularity of the bristling, most of them longer than the diameter of the vein, the one at apex of the subcosta longer than the inner cross vein. Inner cross vein close to middle of the discal cell, outer cross vein not much nearer to the bend of fourth than to inner and about its own length from apex of fifth; third vein with a few basal setulae above and below; apical part of the venation as Figure 55.

Abdomen cylindrical in male, more ovate in female, glossy black, with a narrow anterior marginal patch of whitish dust on each side of second and third tergites which is visible when seen from behind against the light. Surface hairs decumbent and short, discal bristles shorter than apicals. Hypopygium small.

Squamæ as Figure 56, yellow in colour. Halteres with brownish yellow knobs.

Length, 3.5–4 mm.

Holotype, Male, allotype, and one male paratype, Cass, February, 1925 (A. L. Tonnoir).

Genus TRYPHERINA, novum.

This genus is readily distinguished from *Neotryphera* by the narrow frons of the male, in which there are no outer orbital bristles, all being confined to the inner margins of the orbits, and while the female has the frons much broader, about one-third of the head width, the interfrontalia is distinctly narrower than either orbit at middle instead of as wide as these as in *Neotryphera*. In the profile there are also some distinctions (Fig. 57), and the scutellum has a pair of short but quite distinct erect discal bristles, and four or six marginals. The fore tibia in the male has the anterodorsal surface with very short setulae instead of well developed bristles. In other respects there is considerable similarity, but the costal vein is less strongly setulose, and there is a confusing sexual dimorphism in the bristling of the scutellum and abdomen that only careful and extensive examination of specimens in the field will clarify. The eyes are rather densely haired in most specimens.

One female before me bears a label with Hutton's identification as *Tryphera solsilus*, Walker. I can hardly see why one can accept this identification, as Walker makes no mention of the dense grey dust on the thorax and the bases of the abdominal tergites that characterize this species. In fact, his description reads more as if it applied to the preceding species, but I have rejected that possibility because the fulvous yellow palpi of *atra* are quite distinctive, and Walker states that these organs are black in *solsilus*. Accurate identification of Walker's species requires a careful examination of the type specimen if it is in existence.

It would appear necessary to note here that in *Tryphera*, Meigen, the posterior presutural intra-alar bristle is present. This bristle is, as already noted herein, almost invariably lacking in the New Zealand genera that are endemic.

I have before me a number of specimens of both sexes which I am placing as one variable species, the number of scutellar bristles and the degree of width between the apices of the third and fourth veins at their apices being quite variable. In some specimens the first posterior cell is narrowly open, while in others it is closed and short petiolate.

Trypherina grisea, n.sp.

A small black species, with the head and thorax densely pale grey dusted, the abdomen glossy black with the bases of the second

to fourth visible tergites each with a narrow fascia of white dust, black legs, and hyaline wings. The palpi are rather variable in colour, sometimes almost entirely fuscous, to entirely tawny yellow. The squamae are white and the halteres yellow.

Frons of the male at narrowest point, in front of the ocelli, reduced to a mere line, that of the female at vertex over one-fourth of the head width, with the orbits at middle distinctly wider than the interfrontalia at the same point, the male without, the female with, outer proclinate orbitals; head in profile in male as Figure 57. Eyes rather sparsely but quite evidently haired.

Thorax with 2 + 3 dorsocentrals and usually 2 + 1 pairs of acrostichals, the scutellum with 4 or 6 marginal bristles. Possibly I am in error in considering all the females as belonging to one species, but there appear to be no distinctions in the variously bristled males that would justify specific segregations.

Fore tarsi in neither sex widened.

Wing usually with one outstanding bristle on costa at apex of the subcostal vein, which is much longer than inner cross vein. Outer cross vein about midway between inner and curve of fourth vein.

Length, 4-6 mm.

Holotype, Male, Ruapehu, 7.i.22 (Fenwick). Allotype and 2 paratypes, Cass, February and November (A. L. Tonnoir). Paratypes: Balloon Hut, Mt. Grey, Ranfurly, Otago, Purakanui, both sexes. Sixteen specimens.

Genus MACQUARTIA, Robineau-Desvoidy.

I have already dealt with this genus in a paper in this series and have given a summary of the characters. Now with two additional species from New Zealand before me I have little to add to my previous treatment except the presentation of a key to the four species and descriptions of the two new forms. It may be noted, however, that one of the species possesses the same peculiar yellow bristles on parts of the ventral surface and bases of the femora that distinguish one or two species of the genus *Zealandotachina*. In the latter the parafacials are bare below the lower frontal bristle, the head is longer at vibrissae than at base of antenna, and the hypopygial characters are different.

KEY TO THE SPECIES.

1. Both cross veins of the wing brown clouded and the first posterior cell and usually also the discal cell with one or more small dark spots enclosing short vein-like streaks; fore tarsi of the female quite conspicuously widened. *vezata* Hutton
- Both cross veins of the wing unclouded or only the inner one noticeably bordered with brown, and neither the first posterior nor the discal cell with any small brown spots. 2
2. Many of the hairs and bristles on venter of thorax and abdomen, and on coxae and bases of the femora, golden-yellow; fore tarsi of the female quite conspicuously widened; inner cross vein of the wing not clouded. *flavohirta*, n.sp.
- All the hairs and bristles on the above parts black. 3

3. Inner cross vein of the wing quite distinctly clouded with brown; fore tarsi of the female not as much dilated as in the preceding two species, but still distinctly so, basal segment widened from near base to apex. *nigrihirta*, n.sp.
- Inner cross vein of the wing not at all darkened; fore tarsi of female not noticeably dilated, basal segment slender. *claripennis* Malloch

***Macquartia vexata*, Hutton.**

This species is readily distinguished from any other in New Zealand by the presence of dark spots in the wing cells that usually enclose short vein-like lines.

Male, Female. General colour black, slightly shining, with whitish grey dust on the head, more brownish dust on the thorax and abdomen, mesonotum with four rather poorly defined black vittae, abdominal dorsum with irregular large black marks on centre of the tergites in the male, less marked in the female; the dusting checkered; antennae and palpi black; hairs and bristles on thorax, abdomen, and legs black.

Head of male in profile as Figure 58; frons in that sex at vertex about one-seventh of the head width, the orbits without proclinate outer bristles, that of the female nearly one-third of the head width at vertex, widened anteriorly, each orbit with two proclinate outer bristles; face with a weak central vertical carina.

Legs black, the tibiae of female sometimes brownish centrally; fore tarsi quite conspicuously widened, the basal segment gradually widened from near base to apex.

Fourth wing vein more bent in just above preapical angle than usual, much as in *Graphotachina*.

Length, 6–8 mm.

The type-specimen, of which I figure the head and apex of abdomen (Fig. 59) is from Wellington. Other specimens are from Cass, Nelson, and Governor's Bay.

***Macquartia claripennis*, Malloch.**

Originally described from a female which is now before me. This species has the head much as in *vexata*, but the frons is wider, the second antennal segment is much more strongly bristled, and the antennae are considerably longer. The other distinguishing characters are listed in the foregoing key.

I have before me a male which I tentatively refer here, though there are some characters of it that differ so much from those of that sex that I may be in error in allocation. The second antennal segment is not more strongly bristled than usual, the first visible tergite of the abdomen has a pair of apical central bristles, but I can find no trace of the discal pair of the second tergite which are quite prominent in the female. In the exposed hypopygial structures it agrees well with *vexata*. The first posterior cell of the wing has, as in the female, a distinct though rather short petiole, and neither the cross veins nor any of the others are clouded. Frons at vertex one-fourth of the head width.

Length, 10 mm.

Type-locality, Otira. Locality of Male, Waihopai, 23.ix.08, No. 494 (D. Miller).

***Macquartia flavohirta*, n.sp.**

A more slender species than either of the above two, of a general black colour, slightly shining, and quite densely grey dusted, the head on interfrontalia and above the vibrissal angles on the lower part of the parafacials reddish-brown, antennae and palpi black, the latter more yellowish in the female; thoracic dorsum with the usual four black vittae, the abdomen with a large irregular black mark on each tergite in the male, in the female merely black and grey checkered. Wing veins not clouded. Most of the hairs and bristles on the lower part of thorax and abdomen as well as many of those on the coxae and bases of the femora golden-yellow, the others black.

Male, Female. Head higher in comparison with its length than in the two preceding species, the face shallowly bifoveolate, the antennae as long as in *claripennis*. Frons of male at vertex about one-seventh of the head width, that of the female at vertex one-fourth of the head width, bristled as usual.

The dorsocentral bristles 3 + 3, scutellum with six marginal bristles.

Legs black, fore tarsi of the female much widened.

Wings usually with the first posterior cell open, sometimes closed and short petiolate.

Abdomen narrowly ovate in male, broadly ovate in female, in both sexes with a pair of apical central bristles on first to third visible tergites and a pair of discals on second and third. Apex in male similar to that of *vexata*, the sternites not as densely bristled as in that species.

Length, 7-9 mm.

Holotype, Male, and one Male paratype, Riccarton Bush, 10.xi.24.

Allotype, Wellington (D. Miller). Paratypes: Ranfurly, Dunedin, and Flagstaff (D. Miller).

***Macquartia nigrihirta*, n.sp.**

Similar in general habitus to *flavohirta*, but with no yellow hairs or bristles on the thorax, abdomen or legs.

Male, Female. General colour and structure as the preceding species, differing in the male in having the frons at vertex about one-fifth of the head width, the first visible tergite of the abdomen with four apical central bristles, the central two a little in front of the other two, and the apex of the abdomen as Figure 60, the fifth sternite with a pair of short basal processes and the slender backward extensions of the superior forceps much shorter.

The female has the fore tarsi less widened than in the preceding two species, but still obviously widened. The first posterior cell of the wing is open in all the available specimens, and the clouding of the inner cross vein, though it might be considered a trivial character, is constant and valuable in associating the sexes of this species.

Length, 7-9 mm.

Holotype, Male, Leith Valley, Dunedin, 16.xii.09 (D. Miller).
Allotype, Leith Valley, same collector. Paratype females, Ranfurly
and Dunedin (D. Miller).

It appears that the last two species are more closely related to each other than they are to *vexata* and *claripennis*, but without field data it is impossible to make a definite declaration on this point.

Genus *ZEALANDOTACHINA*, novum.

I am placing in this genus a rather composite group of species, some of them with no hairs below the lower frontal bristle and others with hairs to near the lower level of the eyes on the parafacials. It will fall to the lot of some subsequent worker to determine whether this grouping is proper or if it should be modified to the extent that the two groups above indicated should be considered as subgenera or even genera.

The generic characters are as follows: Eyes haired; frons of male much narrower than that of female (ex. *latifrons*); parafacials bare or haired; second segment of the arista not longer than thick; postsutural dorsocentrals 3.

Genotype, *Macquartia subtilis*, Hutton.

KEY TO THE SPECIES.

1. Scutellum with but four strong bristles, the usual basal pair lacking; frons one-fifth of the head width at vertex; hairs on parafacials descending to about midway from base of antenna to vibrissa; antennae entirely black, the third segment but little longer than second; hypopygium without long slender backwardly directed paired processes at bases of the superior forceps. *quadriseta*, n.sp.
- Scutellum with six well developed bristles, the basal and apical pairs usually shorter than the subapical pair. 2
2. Parafacials with fine hairs on less than their upper third. 3
- Parafacials with hairs to at least midway from base of antenna to level of the vibrissa. 11
3. Frons at vertex over one-fourth of the head width, the orbits without outer proclinate bristles. *latifrons*, n.sp.
- Frons at vertex not over one-fifth of the head width, the orbits without proper proclinate bristles. 4
4. Frons at narrowest point not as wide as third antennal segment; parafacial at its narrowest point distinctly wider than the third antennal segment; head with black bristles from vibrissae downward in an oblique series to lower margin of gena in line with anterior edge of the raised portion of the latter, no black bristles on or close to the lower edge behind that series, the genal hairs long, rather fine, and all, or almost all, golden yellow; fore coxae and basal portions of all the femora with some golden yellow bristles usually mixed with the black bristles; pleura and venter of abdomen usually with numerous golden yellow hairs; legs entirely black. *subtilis* (Hutton)

- Frons at narrowest point wider than the third antennal segment and as wide as to twice as wide as the parafacial in profile, or the bristling below the eyes much stronger and mainly black; legs always partly brownish yellow. 5
5. Frons at narrowest point wider than the third antennal segment and twice as wide as narrowest point of the parafacial in profile. 6
- Frons at its narrowest point not as wide as the third antennal segment nor narrowest part of parafacial in profile. 9
6. The bristles on the underside of the costal vein of wing at apex of the subcostal vein over twice as long as the one at same point on the upper side and about twice as long as the inner cross vein; hypopygium without a pair of long slender backwardly directed and densely haired processes; scutellum without distinct discal bristles, the discal hairs short and fine. 7
- The two bristles on the costal vein at apex of the subcosta subequal in length; the one on underside not longer than inner cross vein; scutellum with some outstanding discal setulose hairs or bristles that are distinctly longer and stronger than the other discal hairs. 8
7. Scutellum with six long marginal bristles; first posterior cell of the wing short petiolate. *setigera*, n.sp.
- Scutellum with but four long marginal bristles; first posterior cell of the wing merely closed in margin. *quadriseta*, n.sp.
8. Femora largely yellow; fifth abdominal sternite with the processes fuscous, their surfaces sparsely haired to lower edges and a few longer bristly hairs at apices; hypopygium with a pair of slender backwardly directed processes that are longer than the processes of the fifth sternite, slightly spatulate at apices, and furnished with black hairs that become longer apically. *lamellata*, n.sp.
- Femora almost entirely black; fifth abdominal sternite with the processes largely orange-yellow, their surfaces haired on only outer, or upper, third; hypopygium with a pair of short subtriangular backwardly directed processes that are rather densely black haired. *nigrifemorata*, n.sp.
9. Legs preponderantly black, with at most the tibiae, and usually only the mid and hind pairs, brownish yellow; wings infuscated, most deeply so basally; squamae brown to fuscous; hypopygium without a pair of slender backwardly directed processes. *caripes*, var. *fuscata*, n.var.
- Legs preponderantly yellow, the femora at most partly blackened. 10
10. Hypopygium with a pair of slender apically spatulate backwardly directed long haired processes that are distinctly longer than the processes of the fifth sternite; all four of the black mesonotal vittae seen from behind distinct in front of the suture through the presence of dense grey dust between the submedian pair. *quadrivittata*, n.sp.
- Hypopygium without a pair of long slender processes as described above. *caripes*, n.sp.

11. The long backwardly directed pair of hypopygial processes uniformly slender, densely grey dusted, and long haired on the exposed lower surface; superior hypopygial forceps clothed dorsally with fine dense short black hairs (Fig. 66); fifth abdominal sternite without a short process at base of each arm (Fig. 65). *tenuis*, n.sp.

The long backwardly directed pair of hypopygial processes rather broadly lanceolate, the exposed surface glossy black and long haired only on sides; superior hypopygial forceps with a few short dorsal hairs; fifth sternite with a short stout protuberance at base of each of the lateral arms. *Veluta albicincta*, n.sp.

FEMALES.

1. Legs entirely black. 2
 ♀ Legs with at least the tibiae largely or entirely yellow. 4
2. Glossy black species, the mesonotum with the usual four vittae sooty black on a glossy black ground, the frons velvety or sooty black, shining only on small dots at bases of the bristles; the parafacials, genae on their raised portions, and the bases of second to fourth abdominal tergites, silvery white dusted; parafacials with the fine hairs sparse, descending to about midway between base of antenna and vibrissa; aristae swollen to at least the middle of third segment; fore tarsi uniformly, but not very noticeably thickened from base to apex. *binigra*, n.sp.
- Rather dull black species, the mesonotum and abdomen with greyish or brownish dust, the former with four rather dull black vittae, the frons not sooty black, nor any part of the head or abdomen silvery white dusted; hairs lacking on the parafacials except immediately below the lower frontal bristle; basal fourth of the third segment of the aristae swollen; fore tarsi more conspicuously and not uniformly widened. 3
3. Parafacial very distinctly wider at its narrowest point in profile than the third antennal segment; fore tarsus as in Figure 62. *subtilis* (Hutton).
- Parafacial not as wide at its narrowest point in profile as the third antennal segment; fore tarsus as Figure 64. *infuscata*, n.sp.
4. Fore tarsi with the basal segment not at all widened, the other four segments very slightly so. 5
 Fore tarsi with the basal segment very distinctly widened from at least before the middle to its apex, the second and third segments also distinctly widened. 8
5. Basal two antennal segments brownish yellow, the dust on head and the pleura of almost the same colour; first visible abdominal tergite invariably without apical central bristles in my material. *raripes*, n.sp.
- Antennae entirely black; pleura entirely or predominantly fuscous. 6

6. Scutellum with four strong bristles, the usual basal pair lacking; face including the parafacials, and the frontal orbits, grey dusted. . . *quadriseta*, n.sp.
 Scutellum with six well developed bristles, the apical pair usually the shortest. . . 7
7. Head with dense pale grey dust; thorax entirely black or fuscous and densely grey dusted, with the usual dark dorsal vittae. . . *quadrivittata*, n.sp.
 Head entirely brownish yellow dusted; propleura and lower half of the humeral angles brownish yellow. . . *varipes*, n.sp.
8. Parafacial with some short hairs that extend to or below midway from base of the antenna to the vibrissae; presutural sublateral area of the mesonotum with three or four well developed bristles in a diagonal series; first visible abdominal tergite with a pair of apical central bristles; none of the hairs on the venter of the abdomen golden-yellow, some showing brownish at apices against the light; legs brownish yellow, only the tarsi black. . . *tenuis*, n.sp.
 Parafacial not haired below level of apex of second antennal segment; presutural sublateral area of the mesonotum with only two bristles. . . 9
9. Small species, not over 5 mm. in length; first visible tergite of the abdomen with a pair of well-developed apical central bristles; hairs on entire abdomen black; legs with the exception of the tibiae black, the tibiae faintly brownish yellow. . . *infuscata*, n.sp.
 Larger species, 7-8 mm. in length; first visible tergite of the abdomen without an apical central pair of bristles; hairs on the venter of the abdomen mainly golden-yellow; legs brownish yellow, only the tarsi black. . . *nigrifemorata*, n.sp.

Zealandotachina subtilis (Hutton).

This is evidently a common species, as there are many specimens in the present collection, most of them males. The entirely black antennae and legs (Fig. 62), with the presence of golden-yellow hairs on the genae and their lower edges, as well as many similarly coloured hairs and bristles on the venter of the thorax and abdomen and the coxae and bases of the femora readily distinguish the species from any of its allies.

The frons of the male is not wider than the third segment. The male has usually a pair of strong apical central bristles on the first visible tergite and a pair of discals on the second that are lacking in the female. The male hypopygium has the superior forceps peculiarly formed, their apices seen from the side as in Figure 61, and the posterior extension short and stout; the fifth sternite is not exceptional in form, as shown in the figure referred to.

Length, 7-9.5 mm.

Type-locality: Wellington, from whence I have seen a number of additional specimens in the collection of Dr. Miller. Additional localities: Wilton's Bush, Durville Is., Riwaka, Day's Bay, Silverstream, Stephen's Is., and Pokororo. Taken in November to January.

***Zealandotachina nigrifemorata*, n.sp.**

This species has much the same appearance as the genotype, but there are a number of black bristles on the lower edge of the genae behind the anterior diagonal series below the vibrissa, the tibiae in the male are always brownish yellow, and the legs with the exception of the tarsi are brownish yellow in the female. There are numerous golden-yellow hairs and bristles on the venter of the thorax and abdomen and also on the coxae and bases of the femora as in *subtilis*.

In structure the principal distinctions are to be found in the wider frons of the male, which is distinctly wider than the third antennal segment and about twice as wide as the narrowest point of the parafacial in profile; the lack of any bristle between the usual two on the presutural sublateral area, the much longer antennae, which are about 1.5 times as long as the height of the gena below centre of eye, with the third segment fully 2.5 times as long as the second. The abdomen is the same in general features in both sexes as in *subtilis*, the male having the third and fourth sternites with strong and rather numerous bristles apically, though they are more conspicuous because of the less dense yellow hairs and bristles, and the hypopygium is differently constructed (Fig. 61c). The costal thorn is small as in *subtilis*, and the first posterior cell is generally open.

Length, 6–9 mm.

Holotype, Male, allotype, and 10 paratypes, Cass, February and November (A. L. Tonnoir). Paratypes: Ohakune, Pokako, Wallace-town, Lake Moana, Medford, Dun Mt., and Salisbury's Opening. Twenty-three specimens.

***Zealandotachina varipes*, n.sp.**

This species differs noticeably from the two dealt with above in having no golden-yellow hairs and bristles on the venter of the thorax and abdomen nor on the bases of the femora. It is also marked in the male by the variable amount of brownish yellow colour on the sides of the abdomen, neither of the others having the sides of the abdomen pale, and the abdomen is less checkered on the dorsum, the dusting being more confined to the basal halves of the tergites and their apical halves black. There are a number of male specimens of several types before me which may be accorded varietal rank on the basis of the present material, but further collecting may prove that these are really valid species. I designate them as merely varieties meanwhile and below present a key for their separation. It must also be borne in mind that it is entirely possible that there will be found to be so many intermediate forms in nature that the proposed varietal segregations cannot be maintained. I leave it to subsequent workers to determine the facts.

KEY TO THE VARIETIES.

1. Head in profile seen against the light with the entire frontal orbits and the parafacials to below middle dark velvety brown; wings conspicuously infuscated, darkest at bases and on costa; squamae dark brown, paler on edge of lower one.

- Head in profile with the frontal orbits and parafacials grey dusted, sometimes a little yellowish, but usually almost white; wings and squamae much paler, rarely a little yellowish. 2
- 1a. All femora entirely black. *fuscata*, n.var.
All femora largely yellow. *fumata*, n.var.
2. Fore femora almost entirely black, yellowish only at extreme bases and slightly so ventrally, fore coxae broadly black in front as in *fumata*, and the mid and hind femora marked as in that variety. *varipes*, typical var.
Fore femora with a more or less extensive black dorsal mark that does not extend below middle of posterior surface, the fore coxae usually entirely yellow, and the mid and hind femora with or without black apical dorsal mark. 3
3. Frons at narrowest point about as wide as third antennal segment; the black dorsal stripe on fore femora extending almost from base to apex. *strigipes*, n.var.
Frons at narrowest point about 1.5 times as wide as third antennal segment; the black dorsal stripe on fore femora confined to apical half. *lata*, n.var.

***Zealandotachina varipes*, var. *varipes*, nov.**

This variety is represented by two rather small dark examples in which the frontal orbits are silvery grey and the parafacials are similarly dusted to lower level of the eyes, all the coxae are partly blackened, and the sides of the abdomen are slightly brownish yellow. The wings are slightly browned basally, and the squamae are brownish yellow.

Frons at narrowest point not wider than third antennal segment and slightly wider than the narrowest point of the parafacial, the latter with a few fine hairs below the lower frontal bristle about level of apex of second antennal segment, the third antennal segment hardly longer than the second.

Thorax black, with dense grey dust, the four black mesonotal vittae rather diffuse; seen from behind, the submedian pair narrow, the sublaterals very much wider, both pairs most distinct in front of the suture. Presutural lateral area with but two bristles; sternopleurals 2 + 1.

Legs normal in structure, claws of the fore pair as long as the fourth and fifth tarsal segments combined and longer than the mid and hind pairs.

Wings with the first posterior cell closed in both specimens, but probably variable in this respect, inner cross vein at middle of the discal cell, costal thorn rather well developed.

Abdomen narrowly ovate, slightly depressed, with a pair of apical central bristles on first and second visible tergites, and discals on second and third, the fifth sternite projecting downward keel-like, but more rounded in profile than in the two preceding species.

Female. I am associating with this variety a number of specimens taken at the same time and place which differ markedly from the male in having the legs except the tarsi fulvous to tawny yellow, the second antennal segment brownish yellow, the frontal orbits and face brownish yellow dusted, and the pleura and some part of the abdominal venter of the same general colour.

Length, 5.5–7 mm.

Type, Male, allotype, and 8 paratypes, Cass, November and February (A. L. Tonnoir).

There are three other females, placed separately in the key, in which the second antennal segment is black, and which have some other distinctive characters, but I am uncertain of their varietal association.

Localities, Mt. Arthur and Waiho (A. L. Tonnoir).

***Zealandotachina varipes*, var. *fumata*, nov.**

A much darker variety than the typical one, with the wings blackened basally, the legs more extensively blackened, the squamae dark brown, and the entire frontal orbits and the parafacials to the lower edge of the eye dark velvety brown. In the other characters there is a marked resemblance, the structures being similar.

Length, 7 mm.

Holotype, Male, and one paratype, Salisbury's Opening, 4,000 ft., 16.ii.31 (E. S. Gourlay); one paratype, Otira, 7.ii.22 (A. L. Tonnoir).

***Zealandotachina varipes*, var. *fuscata*, nov.**

This variety is distinguished from all the others by the entirely black femora. The wings are even darker than in *fumata* and so also are the squamae.

Length, 5–6 mm.

Holotype, and one paratype, Waiho, January, 1922 (A. L. Tonnoir). Two paratypes, Ohakune (D. Miller).

***Zealandotachina varipes*, var. *fuscata*, nov.**

This is a markedly paler insect, with the black markings on the femora much more reduced, their extent on the posterior surface never attaining the lower edge, and the mid and hind pairs being frequently without marks.

I figure the dorsal aspect of the left side of the male hypopygium to show the striking distinctions from that of *subtilis*, the superior forceps in particular being very different, consisting of a pair of closely adherent slender processes (Fig. 63).

Length, 7.5–9 mm.

Holotype, Male, Mt. Grey, N. Canterbury, 30.ix.28 (E. S. Gourlay). Paratypes, Mt. Ida, 20.ii.22; Otira, 8.ii.22 (A. L. Tonnoir); Dun Mt., 30.x.21 (A. Philpott); and two without locality labels.

***Zealandotachina varipes*, var. *strigipes*, nov.**

Quite similar to *strigipes* in general characters, but with denser grey dust, that on the face and lower parafacials yellowish, the mesonotum when seen from in front with the vittae merely grey, and the legs with the dark femoral stripe confined to the apical halves of the fore pair.

I should have been inclined, without an examination of the hypopygium, to consider this merely a rather aberrant example of the preceding variety but for the much wider frons, which is about 1.5

times as wide at its narrowest point than the third antennal segment and has the orbits stronger bristled, with one bristle at the upper extremity of the series outwardly curved. The fifth abdominal sternite has the processes in profile even more prominent, and shining black.

Length, 7 mm.

Holotype, Aniseed Valley, 1-4.xii.23 (A. L. Tonnoir).

***Zealandotachina varipes*, var. *lata*, nov.**

A black species, but slightly shiny, with dense pale grey dust on the head, thorax and abdomen, the mesonotum with the usual four black vittae, the submedian pair narrow, the sublateral pair much wider, neither complete, the bases of the abdominal tergites densely pale grey dusted, becoming brownish black at apices. Antennae entirely black, palpi yellow, slightly darkened at apices. Legs black, grey dusted, all trochanters, extreme bases of mid and hind femora, and the entire tibiae tawny yellow. Wings hyaline. Squamae slightly yellowish brown.

Head a little more protuberant at bases of antennae and epistome than in the next preceding species, the frons at vertex in the male one-fourth of the head width, the orbits at middle slightly narrower than the interfrontalia, each with a series of quite strong inner marginal incurved bristles that diverge below, the lowermost about opposite level of apex of second antennal segment and below it some very fine hairs, the uppermost strong and erect, with tip incurved, and with two outer bristles opposite the ocelli that are outwardly curved, the upper one shorter; ocellars well developed, outer verticals about half as long as the stronger inner pair. Eyes with distinct hairs. Third antennal segment about 1.5 as long as second, and nearly twice as wide as narrowest part of the parafacial. Genal hairs and bristles all black, the height of gena at middle about half the length of antenna; palpi longer than the latter, slightly dilated at apices.

Thorax bristled as in *varipes*, the scutellum with six well developed marginal bristles.

Legs normal, the hind femora with much shorter and finer bristles at apices of the posteroventral surface than in *varipes*.

Abdomen narrowly ovate, with the same bristles as in *varipes*, the fifth sternite not as much exposed in profile, the inner edges of the processes narrowly keeled when pressed together.

Length, 6 mm.

Holotype, Waiho, 25.i.22 (A. L. Tonnoir). Abdomen broken off and gummed to a card below the specimen, and some of the legs missing.

***Zealandotachina quadriseta*, n.sp.**

This species is extremely like *setigera*, but it differs from it and all the other species now before me in having but four well-developed scutellar bristles in both sexes, the usual basal pair being absent. Usually when the number of scutellars is reduced in the New Zealand members of this family except in *Trypheringa*, it is the

apical pair and not the basal one that is minute or lacking. In most respects there is a very striking resemblance in the male to *setigera*, but the frons is a little narrower and lacks the outer divergent bristles near the upper extremity of each orbit. The palpi are also in the main dark brown to fuscous. In the only female available the palpi are much paler, almost as in the male of *setigera*, and the frons is normal for this sex. The fore tarsi of the female are as in *varipes*. In both species the bristle on the underside of the costa at apex of the subcostal vein is longer than the inner cross vein.

Length, 6-7 mm.

Holotype, Male, and allotype, Kumara (J. W. Campbell). Paratype, Male, Cass, 28.xi.24 (A. L. Tonnoir).

It might be well to note here that there are no backward extended paired processes to the superior hypopygial processes such as characterize *tenuis* and its allies.

***Zealandotachina infuscata*, n.sp.**

I distinguish this species on the basis of the female only. It is a very small insect, with less evident grey dust on the thorax and abdomen than usual in the genus and only the tibiae partly brownish yellow. The fore tarsi are much dilated (Fig. 64), and the abdomen has distinct pairs of bristles on the apex in centre of the first three visible tergites and a pair of discals on the second and third. The squamae are yellowish white, palpi fuscous, and in general the species is very similar to *varipes* in the chaetotaxy.

Length, 4 mm.

Holotype, Ruapehu, 7.i.22 (Fenwick).

***Zealandotachina quadrivittata*, n.sp.**

A black species, with quite dense grey dust on the thorax and abdomen, the former with the usual four dark vittae, the abdomen changeably checkered with grey and black. Antennae entirely black, palpi fuscous, yellowish at bases in female. The legs are tawny yellow with black tarsi and a dark dorsal stripe on the fore femora.

Frons of male at vertex about as wide as third antennal segment and wider than narrowest part of the parafacial, with moderately strongly inner marginal incurved bristles on entire extent and one upper outwardly curved bristle. Third antennal segment about 1.5 times as long as second, the entire antenna little more than as long as the height of gena. Frons of female at vertex about one-fourth of the head width, much widened to anterior margin, with the usual bristles of that sex.

Abdomen narrowly ovate, with four bristles in centre of apex of first visible tergite, discals on second and third. Fifth sternite with the processes large, longer than wide, rounded at apices, with some moderately long bristles and hairs. Hypopygium with a pair of slender shining black backwardly directed processes that are longer than the processes of the fifth sternite and bristly haired, longer so apically.

Female. Fore tarsi as in *varipes*.

Length, 6-7.5 mm.

Holotype, Male, Ruapehu, 7.i.22 (Fenwick). Allotype, Queens-town (D. Miller). Paratype, Wanganui, 5.i.22 (J. G. Myers).

A female which I place doubtfully here has the palpi much paler than in the other specimens and the frons over one-fourth of the head width at vertex, but it is in other respects so similar that I prefer to consider it as *quadrivittata*.

Locality, Salisbury's Opening, 4,000 ft., 15.ii.31 (E. S. Gourlay).

***Zealandotachina lamellata*, n.sp.**

A smaller species than *quadrivittata*, with the same general colour markings, though the base of the third antennal segment is narrowly red, and in one specimen there is more fuscous colour on the dorsal surface of the fore femora and both the mid and hind pairs are slightly infuscated apically.

Structurally it is distinguished by the wider frons of the male, which at the vertex is one-fifth or more of the head width and has one or two outwardly curved bristles on each orbit near the upper extremity. The first visible abdominal tergite has but two apical central bristles, and the nypopygial pair of backwardly directed processes are rather shorter and less bristly haired.

Length, 6 mm.

Holotype and one paratype, Mt. Grey, N. Canterbury, 30.ix.28 (E. S. Gourlay).

***Zealandotachina tenuis*, n.sp.**

This species differs from all others in the genus by the greater downward extension of the fine hairs on the parafacials, these extending to, or below, the middle. The parafacial is also wider than the third antennal segment and is comparatively less narrowed below than in *varipes* and its closest relatives. The general colour is much as in *quadrivittata*.

Frons of the male at vertex about twice as wide as third antennal segment and wider than narrowest part of the parafacial, with a series of inner marginal incurved bristles and the outer bristling of the upper part quite variable, but usually at least one outwardly curved bristle present. Antennae black, apex of second segment usually brownish yellow. Palpi yellow. Gena as high as antennal length, black haired and bristled.

Thorax bristled as in *subtilis*, usually four bristles in a diagonal series on the presutural lateral area. Scutellars six.

Legs tawny yellow, with a black stripe on dorsum of fore and usually mid femora. Fore tarsi of the female with the basal segment dilated from base to apex, second segment as wide as apex of third, third narrower than second, fourth and fifth not noticeably widened.

Abdomen of male more broadly ovate than in *varipes*, with a pair of long apical central bristles on first visible tergite and at least one pair of discals on second and third, the apex as in Figure 65, the backwardly directed pair of processes not lanceolate, more uniformly slender than in *lamellata* and with much longer hairs

(Fig. 66). The female has a pair of strong apical central bristles on first and second visible tergites and discals on second and third.

Length, 8–10 mm.

Holotype, Male, Mt. Arthur, 4,500 ft., 21.xii.21 (A. L. Tonnoir). Allotype, Ruapehu, 7.i.22 (Fenwick). Paratypes: Salisbury's Opening, 3,600 ft., 6.i.30 (E. S. Gourlay); Ruapehu, 7.i.22 (Fenwick); Flagstaff, Dunedin, 10.xii.21; Otago (D. Miller).

***Zealandotachina latifrons*, n.sp.**

A small species of the same general appearance and colour as *varipes*, var. *lata*, the legs similarly coloured, and the face yellow dusted. The abdomen is also yellowish below basally. The frons, however, is one-fourth of the head width at vertex and much widened in front, while each orbit has two upper outer outwardly directed bristles and in front of these, near middle of orbit, one proclinate bristle, much as in typical females of the genus. The abdomen has the pair of apical central bristles on the first visible tergite and the pair of discals on the second reduced to mere short bristly hairs, which is never the case in any variety of *varipes* seen by me. The first posterior cell of the wing is short petiolate, but this character is not of much value in this genus, there being much variation in this part of the venation.

Length, 4–5 mm.

Holotype, no data (Coll. D. Miller).

Subgenus CALOSIA, novum.

I am erecting for a single female specimen this subgenus on the basis of the following characters distinguishing it from typical *Zealandotachina*: Parafacials almost as in *Z. tenuis*, with some hairs descending to middle, aristae inserted about one-third from base of third antennal segment, thickened to well beyond the middle of third segment, fore tarsi slightly and uniformly thickened from base to apex.

***Zealandotachina (Calosia) binigra*, n.sp.**

A very pretty small deep black species, with the frons sooty or velvety black except on minute shining dots at bases of the bristles; the parafacials except at upper and lower extremities, the lower half of back of head, and the raised part of the genae, silvery white dusted; antennae and palpi black. Thorax glossy black, with the four mesonotal vittae sooty or velvety black, interrupted at suture and not continued to hind margin, the posterior half of the mesopleura and upper part of the sternopleura silvery white dusted. Abdomen glossy black, with silvery white dust on bases of second to fourth tergites inclusive, the dust appearing interrupted when seen from different angles on second and third, and widely interrupted on middle on fourth tergite. Legs black. Wings brownish hyaline. Squamae white. Knobs of halteres pale yellow.

Frons at vertex nearly one-third of the head width, widened in front, each orbit with three outer bristles, the anterior one proclinate, the other two more outwardly curved. Antennae about as

long as face, third segment about 1.5 times as long as second, wider at apex than width of parafacial. Eyes sparsely long haired. Gena at centre about as high as length of third antennal segment.

Thorax with the usual bristling, the scutellum more raised on disc than usual, with six marginal bristles.

Legs rather stout, fore tibia with a closely set series of short bristles on anterodorsal surface from base to apex, 9-10 in number, that gradually increase in length apically.

Abdomen broadly ovate, segments subequal, first to third tergites with a pair of apical central bristles, second and third with a pair of discals.

Length, 4.5 mm.

Holotype, Blackball, March 20.

The discovery of the male of this species will determine if I am justified in considering it as entitled to subgeneric segregation.

It is probable that many more species of this genus will be found in the country, and a careful study of the hypopygia of the males coupled with information on the habits of the larvae is required to throw light on their classification. This I am unable to undertake, and it will fall to some New Zealand worker to check up my findings as presented above, which I hardly dare to hope will be sustained in their entirety.

Genus MEDINELLA, novum.

This genus is readily distinguished from its near relatives in New Zealand by the lack of distinct hairs on the eyes in both sexes and the presence near the base of the posteroventral surface of the mid femur of a single exceptionally strong, downwardly directed bristle. In the bristling of the thorax there is some variation in the different species of the genus, the apical pair of scutellar bristles being sometimes about half as long as the next pair and sometimes practically absent. In one case only are there distinct discal scutellar bristles present, and there are four of the specimens before me in which the posterior presutural intra-alar bristle is present though rather weak. This last character is very exceptional in the New Zealand members of the family, but without a better representation of local material I do not care to magnify its importance in the present case.

Genotype, *Medinella unispinosa*, n.sp.

KEY TO THE SPECIES.

- | | |
|-------------------|---|
| 1. Males. | 2 |
| Females. | 5 |
2. Hypopygium with a pair of long slender rather densely black haired processes that extend backward to posterior margin of the sixth visible tergite (Fig. 68); fifth sternite large, the processes broad, their inner edges depressed, the apical part forming a sharp glossy ridge, and at base of each a small thumb-like inwardly directed process; apical pair of scutellar bristles about half as long as preapical pair.

- Hypopygium without a pair of long slender processes as described above, or if such are present they are not densely haired; fifth sternite with the processes much narrower apically, ending in a rather slender downwardly curved point; apical pair of scutellar bristles minute. 4
3. Legs black, tibiae brownish yellow; abdomen glossy black, with white slightly checkered dust that does not extend to apices of the tergites. *nigrifemorata*, n.sp.
 Legs fulvous yellow, only the tarsi black; abdomen not as glossy, with brownish grey to brown dust that is slightly checkered and continued to apices of the tergites. *flavofemorata*, n.sp.
4. Frontal orbits and parafacials densely silvery white dusted; frons seen from the side and slightly in front entirely white dusted. *albifrons*, n.sp.
 Frontal orbits and parafacials brown dusted, the latter yellowish grey below; frons seen from the side and slightly in front brown dusted. *varipes*, n.sp.
5. Apical pair of scutellar bristles about half as long as the preapical pair. *flavofemorata*, n.sp.
 Apical pair of scutellar bristles reduced to short hairs that are not nearly half as long as the preapical bristles. *varipes*, n.sp.

***Medinella nigrifemorata*, n.sp.**

Male. A black species, with the tibiae dirty yellow, darker at bases, the squamae white, halteres yellow, and the wings slightly brownish hyaline. The frontal orbits and parafacials are silvery white dusted, the genae almost as densely dusted, becoming less so behind, the antennae black, and the palpi concolorous. The thorax is dark grey dusted, with the usual four dark vittae on the mesonotum poorly defined, and the abdomen is almost glossy, with greyish white dust at the bases of the second to fourth visible tergites that is slightly checkered and does not extend distinctly to apices.

Head in profile as Figure 67. Frons at vertex not over one-sixth of the head width, the orbits narrower at narrowest point than the interfrontalia at same point, with a series of incurved inner marginal bristles of moderate length and one outwardly curved upper bristle; all four verticals distinct though not strong, the ocellars not well developed; lower frontal bristle opposite base of antenna; parafacials bare. Eyes almost entirely devoid of hairs.

Thorax with the dorsocentrals 3 + 3, 2 pairs of presutural acrostichals, the prealar long, the posterior presutural intra-alar lacking, sternopleurals 2 + 1, scutellum with six marginal bristles, the apical pair longer than the basal pair, and no discals present.

Legs rather stout, the mid femur with the single posteroventral bristle near base about as long as diameter of the femur; hind tibia with one bristle in the anterodorsal and another in the posterodorsal series beyond middle much longer than the others.

Both costal thorns fully as long as the inner cross vein; section of costa between apices of subcostal and first veins not half as long as the preceding one; outer cross vein nearly three times as far from inner cross vein as from bend of fourth, the fourth almost straight and oblique beyond the bend, ending a little before wing tip, the first posterior cell open; third vein with a few setulae at extreme base above and below.

Abdomen subcylindrical, slightly tapered to apex; first visible tergite with a pair of long apical central bristles, second with a similar pair of discals and a pair of central apicals, third with a pair of discals and an almost complete apical series, fourth with three or four irregular series of long bristles, fifth concealed, sixth moderately bristly, seventh weakly haired, the long pair of finely haired slender hypopygial processes extending proximad of apex of sixth tergite; fifth sternite large, processes broad at apices, depressed along inner edges and raised into a thin plate at apices, below which is glossy black, the outer exposed parts grey dusted and with bristly hairs which become longer at apices, each process with a short inwardly directed projection at base on inner edge.

Lower squamae widened behind, broadly rounded at apex.

Length, 6 mm.

Holotype, Mt. Arthur, 5,000 ft., 23.xii.21 (A. L. Tonnoir).

An aberrant specimen which may belong here has two strong bristles on the basal half of the posteroventral surface of the mid femur, and no apical bristles on the scutellum. It may really belong to a distinct species, but the other characters are in such close agreement that I leave the single male available tentatively as *nigrifemorata*.

Locality, Arthur's P., 9.xii.20 (E. H. A.).

***Medinella flavofemorata*, n.sp.**

Very similar to the preceding species, differing essentially in the yellow legs, of which only the tarsi are black, the more brownish than grey dust of the thorax and abdomen, more especially of the latter, and its greater extension over the tergites. The palpi are also paler, yellowish at bases.

In structure there is very little distinction, though the first posterior cell of the wing is narrower at apex, the fifth abdominal sternite has more bristly armature, and there are more and stronger hairs on the fourth sternite (Fig. 68).

Length, 6 mm.

Holotype, Male, Cass, 28.xi.24 (A. L. Tonnoir). Paratype, No. 831, Flagstaff Hill, Dunedin, 29.xii.12 (D. Miller); Astrolabe, Nelson, 1.i.12 (D. Miller); Nelson, Oct. 17 (A. L. Tonnoir), and one from Dr. Miller's collection with No. 278b.

One female which I place with this species differs in having the frons at the vertex about one-fourth of the head width, each orbit with two outwardly curved upper and one proclinate lower bristles on the upper half laterad of the inner marginal bristles, the abdomen rather broadly ovate, with a pair of central apical bristles on the first and second visible tergites, and a pair of discals on second and third. The fore tarsi are very slightly dilated beyond the basal segment.

Locality, Astrolabe, Nelson, 1.i.12 (D. Miller).

***Medinella albifrons*, n.sp.**

Male. A small black species, with the head densely white dusted, the frontal orbits and parafacials more or less silvery, the antennae

black, palpi black with a yellowish tinge at bases, thorax with four black dorsal vittae, the sublateral pair interrupted in front and at suture, the scutellum brown at base, abdomen with dense grey dusting like the thorax, with first to third visible tergites each black or dark brown at apices, more broadly so centrally, the fourth less noticeably dark at apex; legs black, grey dusted, mid and hind femora at bases and all of the tibiae brownish yellow. Wings greyish hyaline, veins fuscous. Calyptrae white.

Head in profile as in *nigrifemorata*. Frons at narrowest point about one-sixth of the head width, the orbits about as wide as, or wider than, the interfrontalia, all densely white or greyish white dusted, the bristling rather strong, similar to that of *nigrifemorata*, the ocellars about as long as the upper orbitals. Genal bristling strong below.

Legs stout, bristled as in *nigrifemorata*.

Costal thorn long, venation much as in *nigrifemorata*, but the outer cross vein is not over twice as far from inner as it is from the preapical angle of fourth vein; first posterior cell open, ending a little in front of wing tip.

Abdomen subcylindrical, tapered to apex, with the dorsal bristling strong and similar in arrangement to that of *nigrifemorata*. Fifth sternite with the processes as Figure 69, the hypopygium with a pair of slender, inconspicuous, backwardly directed processes that are slightly spatulate at apices and furnished with a few very short fine hairs.

Length, 5 mm.

Holotype, Cass, February, 1925 (A. L. Tonnoir).

A second specimen, in rather damaged condition, differs from the type in being darker coloured, with the mesonotal vittae and the dorsal dark marks on the abdomen more extensive. Both have the posterior presutural intra-alar bristle present and stronger than in the next species.

Locality, Queenstown, Otago, 22.ii.12 (D. Miller).

***Medinella varipes*, n.sp.**

Male. A much darker species than *albifrons*, with the frontal orbits and upper half or more of the parafacials brown dusted, the thoracic dorsum and abdominal tergites more diffusely marked, and the mid and hind femora and trochanters more conspicuously yellow. The structures are very similar, but the bristling is finer and the disc of the scutellum has only one or two setulose hairs besides the short hairs instead of several rather noticeable bristles. The fifth sternite is also more triangular at apices of the processes.

Female. Similar to the female of *flavofemorata*, differing as noted in key.

Length, 5 mm.

Holotype, Male, Cass, February, 1925 (A. L. Tonnoir). Allotype, and 1 paratype, Greenstone R., 1.i.21 (Fenwick). Paratype, Male, damaged, Kawari Is. (D. Miller).

Genus *GRAPHOTACHINA*, novum.

This genus belongs to that group in which there are no hairs on the parafacials below level of the base of antennae, the face is shallowly bifoveolate, the parafacial in profile is about as wide as the third antennal segment, the eyes are distinctly haired, the frons of the male is about one-third of the head width, and the second segment of the arista is about twice as long as thick. The scutellum has usually six marginal bristles and the postsutural dorsocentrals are in three or four pairs, generally the latter. The abdomen is moderately broad ovate, with apical bristles on all visible tergites, and discals on all but the first. The distinguishing character lies in the wing venation, the fourth vein beyond the preapical angle being very much incurved into the cell just above the angle, and the outer cross vein is much bent (Fig. 70).

Genotype, the following new species.

Graphotachina sinuata, n.sp.

Male, Female. Head reddish brown, raised part of the genae, the occiput, and frontal orbits black or fuscous, the interfrontalia dull black, the orbits, parafacials and genae silvery white dusted, the intensity of the dusting varying according to the angle from which it is seen; antennae black, basal two segments brown, base of third narrowly red; palpi fuscous, reddish basally. Frons of male at vertex over one-fourth of the head width, widened anteriorly, the orbits linear above, widened in front, with an inner marginal series of strong incurved bristles and two or three outer bristles on upper half that are sometimes almost proclinate; frons of the female a little wider than that of the male, with two or three outer proclinate bristles on upper half and a series of inner marginal incurved bristles as in the male. Profile as Figure 71.

Thorax black, with changeable silvery white dusting, the mesonotum with four black vittae, humeral angles and scutellum largely red. Dorsocentrals usually 3 + 4; three pairs of acrostichals in front, the posterior pair rather close to the suture.

Legs in male black, the tibiae brownish yellow; in female the femora are also largely brownish yellow. Bristling as usual; fore tarsi of female very little wider than the mid pair.

Wings hyaline, veins black, with a fuscous cloud at base of costa to just beyond humeral cross vein, another beginning at apices of basal cells, most evident on costa and along the veins, fading out about middle, but the cross veins and other veins more or less dark margined. Apical venation as Figure 70. Costal thorn not developed; third vein haired at base above and below.

Abdomen coloured as thorax, in the male with some red on sides of most of the tergites, on base of fourth, and the hypopygium and fifth sternite, the bases of all tergites rather broadly silvery white dusted, the intensity changing with the angle from which the surface is viewed. Processes of fifth sternite broad, rounded at apices, without exceptional armature; hypopygium with two rather short slender finely-haired backwardly-directed processes.

Squamae white, margins yellowish. Halteres brownish yellow.

Length, 8–10 mm.

Holotype, Male, and one Male paratype, Mt. Arthur, 5,000 ft., 23.xii.21 (A. L. Tonnoir). Allotype, without data, in my collection.

Genus *CAMPYLIA*, novum.

This genus might possibly be accorded merely subgeneric rank within *Zealandotachina*, but definite allocation must await further investigation of the relationships of the whole family in New Zealand. The peculiar third antennal segment, which is somewhat like that of some species of *Heteria*, is quite distinct, at least in the male, from that of any species of the closely related genera, the concavity of the upper edge being in many examples even more marked than shown in Figure 72, and the elongated second aristal segment, with the noticeable elbowing of the third and second at their junction is also noteworthy.

Genotype, *Calcager temerarum*, Hutton.

Campylia temerarum (Hutton).

The type-specimen of this species, which I have before me, is a female in good condition. In this sex the third antennal segment is not as wide as in the male, and second segment of the arista is not as much elongated. The legs except the tarsi are entirely fulvous yellow, the fore tarsi have the basal segment undilated and the second to fifth quite distinctly though not greatly dilated. The first posterior cell of the wing is closed and short petiolate, and the outer cross vein is over twice as far from the inner as from the bend of the fourth vein. The palpi are long, slightly dilated at apices, fulvous yellow, with their tips slightly infuscated.

It is rather unfortunate that the type-specimen is a female, as it is thus at present impossible to definitely associate it with one of the various types of the other sex available to me. I have made an attempt to determine species on the basis of both sexes in this collection, but accurate associations and specific limits must await more detailed work on more material than I now have and it would be preferable that such be supported by field work on the life-histories of the forms involved. My deductions as to possible species are presented below, with a key to the diagnostic characters.

KEY TO THE SPECIES.

- | | |
|--|---------------------------|
| 1. Females. | 2 |
| Males. | 3 |
| 2. First visible abdominal tergite with a pair of well-developed apical central bristles. | <i>temerarum</i> (Hutton) |
| First visible abdominal tergite without a pair of apical central bristles. | sp.? |
| 3. Frontal orbits with no outwardly curved bristles or at most one short one near the upper extremity. | <i>nudarum</i> , n.sp. |
| Frontal orbits each with from one to three strong outwardly curved outer bristles on the upper half or less. | 4 |
| 4. The anterior outer orbital bristle proclinate. | <i>temerarum</i> (Hutton) |
| The anterior outer orbital bristle divergent. | sp.? |

I have arbitrarily determined as the male of *temerarum* some specimens in which there is an anterior proclinate orbital bristle (Fig. 72) and the apex of the inferior forceps of the hypopygium is as Figure 73.

Length, 6-7.5 mm.

Type locality, Christchurch. Other localities, Cass, Weraroa, Mt. Cargill, Nelson, and Aniseed Valley.

***Campylia nudarum*, n.sp.**

This species differs from *temerarum* as noted in the above synopsis and in the much wider apical half of the inferior hypopygial forceps of the male (Fig. 74a). It is to be noted that there is considerable variation in the colour of the legs, in most specimens the femora being almost entirely black, densely grey dusted, but in others they are blackened only apically or even entirely tawny yellow as in the females. I do not attach much importance to the character, but leave the matter of its significance, if any, to future students of the group. The ventral view of the fifth abdominal sternite in both species is as Figure 74b.

Length, 6-7 mm.

Holotype, Male, Nihotapu, 23.ii.23 (A. L. Tonnoir). Paratype males, Reu Lake, Ben Lomond, Lake Brunner, Weraroa, Dunedin.

***Campylia* sp.**

This species, which is represented by two males, has the armature of the frontal orbits intermediate between those of the two preceding forms, there being one strong outwardly directed upper outer bristle on each orbit. It is entirely probable that this is a good species, but I leave it tentatively as above, and hope that it may be possible for someone to definitely determine its status.

Length, 7 mm.

Localities, Cass, February, 1925 (A. L. Tonnoir); Mt. Arthur, 23.ii.21 (A. Philpott).

Genus NEOTACHINA, novum.

This genus has much in common with *Platytachina*, but is readily distinguished from it by the distinctly bifoveolate face in both the subgenera. In one subgenus the number of scutellars is invariably 6, while in the other there is some variation, either 6 or 8 being present. In the latter subgenus the fifth visible tergite of the abdomen is broadly exposed, being in both the species now before me about as long as the sixth and separated from the latter by a depression rather than a suture. I prefer to associate this subgenus with *Neotachina* rather than with *Platytachina* because of the distinctly bifoveolate face. For other characters of the genus and subgenera see the key to the species and descriptions given below.

Genotype, *Neotachina obtusa*, n.sp.

KEY TO THE SPECIES.

MALES.

1. Fifth abdominal tergite either entirely concealed or reduced to a very narrow transverse strip that is not over one-sixth as long in centre as the sixth tergites. (Subgenus *Neotachina*) .. 2
 Fifth abdominal tergite broadly exposed, about as long as the sixth in centre. (Subgenus *Tachineo*) .. 4
2. Parafacials haired to lower level of eyes close to anterior edge of latter; frons at its narrowest point in front of the ocelli not nearly as wide as third antennal segment; tarsal claws rather blunt at apices. .. *obtusa*, n.sp.
 Parafacials haired to or slightly below middle; frons at its narrowest point in front of the ocelli usually as wide as, or wider than, the third antennal segment; tarsal claws acutely pointed at apices. .. 3
3. Third antennal segment fully twice as long as its greatest width and as wide as narrowest part of frons. .. *angusticornis*, n.sp.
 Third antennal segment not twice as long as wide and distinctly narrower than narrowest part of frons. .. *laticornis*, n.sp.
4. Abdomen metallic dark blue, nowhere red nor distinctly dusted; antennae with the third segment predominantly orange-yellow, stained with brown basally; parafacial haired to, or almost to, lower level of eye, the hairs coarse; dust on centre of parafacial golden-yellow; most of the wing veins suffused with pale brown. .. *clarki* (Hutton)
 Abdomen black, with a slight bronzy tinge, broadly red on sides basally, and with distinct, though not dense, grey dust; third antennal segment predominantly black; parafacial with fine hairs on upper half, the dust centrally brownish yellow; none of the wing veins suffused with brown. .. *depressa*, n.sp.

Subgenus NEOTACHINA, s. str.

***Neotachina (Neotachina) obtusa*, n.sp.**

A robust species of predominantly black colour, with distinct grey dust on head, thorax and abdomen, the thorax distinctly quadrivittate with black, the sides of the abdomen partly reddish yellow on basal half, the dust checkered on dorsum. Legs black, the hind tibiae showing only slightly brownish. Wings hyaline, the alulae or anal lobes white. Squamae yellowish white, with white fringe. Halteres brown.

Head fuscous, the ground colour in facial foveae and vibrissal region red. Antennae black, third segment narrowly red at base on inner side; palpi brownish yellow. Frons black, lunule reddish brown, orbits, parafacials, and raised part of genae, pale grey dusted. Width of frons at narrowest point not half as great as that of third antennal segment, the hairs ceasing a short distance from anterior ocellus; ocellar bristles and inner verticals well developed, the latter cruciate in type; parafacial in profile over twice as wide as third antennal segment and about half as wide as eye, the latter distinctly haired, the hairs on parafacials descending to lower level of eye; antennae hardly longer than width of parafacial and much shorter than height of gena at centre; second segment of the arista about as long as thick, third tapered from base to beyond middle;

gena at centre about half as high as eye; palpi longer than antennae; apical section of the proboscis slender, nearly as long as eye height; face rather markedly bifoveolate, the central carina visible in profile beyond edge of the parafacial; antennae inserted below middle of eye in profile.

Scutellum entirely black, with changeable grey dust, and six marginal bristles, some of the hairs on apical half of disc very long. Presutural lateral area with two bristles; posterior notopleural bristle duplicated as in most males of the subgenus; sternopleurals 2 + 1.

Legs black, the tarsal claws blunt-tipped.

Wings with the usual venation, the first posterior cell open, the inner cross vein distinctly proximad of level of apex of first vein, second section of costa as long as fourth and half as long as first; some fine hairs at base of third vein both above and below; costal thorn undeveloped.

Abdomen broadly ovate, slightly flattened on dorsum, the first visible tergite with a pair of apical central bristles, second with a pair of discals and four or more in centre of apex, third with four or more discals and a complete apical series; hypopygium slightly bulbous, the basal segment with short fine hairs; fifth sternite with the processes slightly emarginate (Fig. 75), the other sternites rather numerously bristled.

Length, 13 mm.

Holotype, Male, Mt. Arthur, January 24 (A. Philpott).

In addition to the distinguishing characters listed in the key the entirely black legs and yellowish white squamae serve to separate this species from any of the others in the genus now before me.

I have a female before me which I take to be that of *obtusa*. It is the only one in which the legs are entirely black and the squamae are yellowish white. The scutellum is also entirely black, and though there are only a few scattered hairs on the lower half of the parafacials close to the eyes, I have no doubt that it belongs to this species. The claws are pointed, and the abdomen is not red on the sides.

Length, 14 mm.

Locality, Mt. Cook, 4.xi.29 (A. Philpott).

This may be considered as the allotype.

Neotachina (*Neotachina*) *angusticornis*, n.sp.

Very similar to *obtusa* in general appearance, differing markedly in having the tibiae brownish yellow, the scutellum usually showing brown or red on the apical half, the parafacials haired on only their upper halves, and the tarsal claws acutely pointed. The squamae are also brown.

Frons at narrowest point not half as wide as narrowest part of the parafacial, the orbits and upper part of the parafacials with brassy yellow dust. Antennae rather variable in colour, the third segment usually red on at least its base, its width not less than equal to that of narrowest part of frons. Parafacials haired to middle, the hairs extending fully across, not prolonged downwards close to eye.

Scutellum usually reddish brown on apical half, the thorax similar in other characters to that of *obtusa*.

Legs black, all the tibiae brownish yellow.

Abdomen black, with checkered grey dust, the sides quite broadly brownish yellow basally. First visible tergite with at most a pair of very inconspicuous apical central bristles and the discals on second also rather short and fine.

Squamae and their fringes brown.

Length, 11-13 mm.

Holotype, Male, Flora Camp, 15.ii.31, 3,000 ft. (E. S. Gourlay). Paratypes, Ohakune (Harris); Otira, 5.i.23 (J. G. Myers).

I have several females before me that belong to either this or the next species. These differ from the female of *obtusa* in having the tibiae brownish yellow, the apex of the scutellum similarly coloured, and the hairs on the parafacials not descending to lowest level of the eyes. In neither species are the fore tarsi at all widened.

Length, 12-13.5 mm.

Localities, Mt. Arthur, Dun Mt., and Salisbury's Opening.

Field association of the sexes is desirable to establish specific identities of the two species.

***Neotachina (Neotachina) laticornis*, n.sp.**

This species is very similar to *angusticornis*, differing mainly in having the antennae larger, with the third segment wider, and the frons very distinctly wider than the latter.

It is entirely possible that the two are merely variants of a single species, but the specimens separate on the characters given, and tentatively I give them distinct specific rank.

Length, 12-13 mm.

Holotype, Male, Flora Camp, 16.ii.31, 3,000 ft. (E. S. Gourlay). Paratypes, Mt. Arthur, 3 males.

Subgenus TACHINEO novum.

For diagnosis see specific description.

Genotype, *Tachina clarki* Hutton.

***Neotachina (Tachineo) clarki* (Hutton).**

This species was originally described as *Tachina clarki*, but there is no species of that genus, nor in fact closely related thereto, found so far in New Zealand. The type specimen is a male that differs from any in the genus in being mainly of a metallic dark blue colour, the abdomen being entirely of that shade though the thorax is almost black. The bright orange-yellow basal scale of the wings reminds one of the genus *Occisor*, but in other characters this species is quite different, especially in the much narrower frons of the male and the more broadly ovate abdomen in the same sex.

The specimen is slightly stained, but the antennae are evidently paler than in any of the other species, the third segment being mainly orange-yellow, and the parafacials have the dust dense and golden-yellow centrally. The frons at its narrowest point is wider

than the third antennal segment and narrower than the parafacial at its narrowest part; the latter has coarse hairs that descend to lower level of the eye, the eyes are haired, and the third segment of the arista is swollen on its basal third. Gena fully half as high as eye.

Thorax with the bristling much as in *obtusa*, some long hairs adjacent to the posterior notopleural bristle, and a number of long marginal and apical discal hairs on the scutellum.

The legs are largely broken off in the type, but those that remain are black with reddish yellow tibiae.

The wings are brownish hyaline, with slight but evident brown suffusion along most of the veins.

The abdomen has no distinct dust on the dorsum and is abnormal in form, the apex having apparently been damaged, as the third visible tergite is present on only the left side, being eliminated on the right, or fused with the fourth there. The apex of the first tergite and disc of second lack bristles.

Upper squama greyish white, lower one and fringe brown. Halteres yellow.

Length, 12 mm.

Type locality, Christchurch. I have seen only the type specimen.

***Neotachina (Tachineo) depressa*, n.sp.**

A shiny black species, with the sides of the abdomen reddish brown basally, the third antennal segment fuscous, yellowish at base, the dorsum of the abdomen quite evenly and lightly grey dusted, the dust not checkered, and the squamae pale yellowish brown with paler fringes.

Head much as in *clarki*, but the parafacials are narrower, dark velvety brown on upper third, yellowish dusted below, more nearly grey dusted close to the eyes, and the aristae are longer, being distinctly longer than the antennae. The hairs on the parafacials disappear at middle, and the frons is a little narrower.

Thorax black, with dark grey dust and four rather indistinct black dorsal vittae, the bristling as in *clarki*, the bristles on the presutural lateral area 3, the posterior notopleural not duplicated, and numerous long bristly hairs on the sides and disc of the scutellum besides the six marginal bristles.

Legs black, tibiae reddish yellow.

Wings greyish hyaline, veins not at all margined with brown.

Abdomen more flattened on dorsum than usual, first and second tergites without bristles.

Length, 14 mm.

Holotype, Male, Mt. Arthur, 1.xii.25, 4,500 ft. (A. Philpott).

A PRELIMINARY KEY TO THE GENERA OF TACHINIDAE OF NEW ZEALAND.

In the following key I have included only those genera that are known to me as occurring in New Zealand. Some others have been reported, but an examination of the specimens that the records were based upon has proven that the specimens were misidentified as to genera.

1. Posterior margin of the thorax with a heavily sclerotized plate extending from below base of the abdomen to above the hind coxae, which is evenly convex (Tribe *Cylindromyini*). 2
 Posterior margin of the thorax not evenly convex nor uniformly sclerotized from below base of abdomen to above hind coxae, centrally membranous and soft, generally sunken or wrinkled. 3
2. Sternopleura with one strong bristle; eye not emarginate behind. *Huttonobesseria*, Curran
 Sternopleura with two strong bristles; eye slightly emarginate behind. *Eivibrissa*, Rondani
3. Abdomen without well developed dorsal bristles (Tribe *Phasiini*). *Hyalomyia*, Robineau-Desvoidy
 Abdomen with well-developed bristles on the dorsum, at least at the apices of the third and fourth visible tergites. 4
4. Ultimate section of fifth vein usually half as long as penultimate, sometimes much longer than that; outer cross vein usually retracted posteriorly; scutellum with some erect discal bristles (Tribe *Vorini*). 5
 Ultimate section of fifth vein usually less than one-third as long as the penultimate one; outer cross vein not much retracted posteriorly; scutellum without erect discal bristles, sometimes the apical marginals curved upwards. 8
5. First wing vein strongly setulose or bristled on upper side centrally. *Calcageria*, Curran
 First wing vein bare above. 6
6. First posterior cell of the wing closed and usually with a long petiole ending close to tip of the wing. *Uclesiella*, n.gen.
 First posterior cell of the wing open, ending well before the wing tip. 7
7. Abdomen with discal bristles on second to fourth visible tergites. *Calcager*, Hutton
 Abdomen without discal bristles on second and third visible tergites. *Plagiomyia*, Curran
8. Prosternum setulose; facial ridges strongly bristled from vibrissae to above middle; parafacials bare; eyes haired. *Cerosomyia*, Hutton
 Prosternum bare; facial ridges rarely bristled on lower half. 9
9. Posterior presutural intra-alar bristle strong; ocellars undeveloped in either sex; vibrissae from one-third to one-half the distance from lower to upper margin of head in profile, with no setulae above them narrowly separated, and below each a series of evenly spaced almost equally strong bristles on sides of the narrowly separated genal edges (Fig. 76); angle of fourth vein with a continuation of vein that is not shorter than the section of vein between angle and outer cross vein. *Macrophthalma*,

- Posterior presutural intra-alar bristle lacking, rarely represented by a fine setula; vibrissae very much nearer to lower level of head in profile, the bristling not as above; and the angle of fourth vein either without a spur vein or if one is present it is very much shorter. 9a
- 9a. Basal segment of the arista not less than three times as long as thick, and as long as the second segment, the two combined varying from half as long to as long as the third segment. *Heteria*, Malloch
- Basal segment of the arista rarely longer than thick and if so much shorter than the second when the latter is much elongated, the two combined much shorter than the third segment unless when the second is exceptionally elongated. 10
10. Basal section of the stem vein of the wing with a fringe of setulose hairs on its posterior side above. *Hexamera*, Brauer and Bergenstamm
- Basal section of stem vein of the wing without such setulose hairs. 11
11. Fourth wing vein incomplete, lacking beyond the point where it usually bends forward towards third. *Truphia*, Malloch
- Fourth wing vein complete, sometimes fusing with third before its apex. 12
12. Parafacials with distinct hairs or bristles to much below level of the lowest bristles of the invading frontal series, and always to below level of the arisal insertion, frequently to lowest level of eyes, or if this character is doubtful the parafacial in profile is about as wide as eye. 13
- Parafacials bare or with very few fine hairs slightly below lowest frontal bristles, never haired to mid-way from antennal insertions to lower margin of eye; parafacial at middle rarely more than half as wide as the eye. 36
13. Third antennal segment not longer than second, the latter slender, longer than usual; first posterior cell of the wing closed and with a short petiole. *Engycera*, n.gen.
- Third antennal segment distinctly longer than second, if subequal in length, then the first posterior cell of the wing is rather widely open. 13a
- 13a. Second segment of the arista rarely less than five times as long as thick, frequently half as long as third segment, when doubtfully five times as long as thick the first posterior cell of the wing is closed and petiolate, with the petiole usually in direct continuation of the third vein and ending close to the wing tip; and in all cases no hairs below lower squama. 14
- Second segment of the arista not, or very little, longer than thick, rarely over twice as long as its diameter; first posterior cell of the wing generally open, never with a long petiole extending to near wing tip; some microscopic hairs just below base of lower squama. 18
14. First posterior cell of the wing open; parafacials finely and rather densely long haired; gena about as high as eye. *Calotachina*, n.gen.
- First posterior cell of the wing closed, sometimes just at the margin of wing. 15

*An introduced North American genus.

15. Ultimate section of fifth vein over one-third as long as the penultimate one; petiole of first posterior cell long, continued in line with third vein almost to the exact wing tip; third vein setulose above to or almost to inner cross vein. *Genotriohia*, n.gen. 16
- Ultimate section of fifth vein much less than one-third as long as penultimate. 16
16. Third wing vein setulose to, or almost to, the inner cross vein; sutures between abdominal tergites 2 and 3 and 3 and 4 fused centrally; sternopleura with three strong closely placed bristles. *Wattia*, n.gen. 17
- Third wing vein with but two or three bristles at base above; all abdominal sutures complete and distinct; sternopleura with at least 4 bristles. 17
17. Abdomen with a bare longitudinal strip on dorsum between the central pairs of bristles; parafacials with a single series of bristles; apical pair of scutellar bristles curved upward and forward. *Arthuria*, n.gen. 18a
- Abdomen haired or setulose on its entire dorsal surface; parafacials with several series of bristles and long hairs; apical pair of scutellar bristles directed backward. *Microhystrioidia*, n.gen. 18b
18. First visible abdominal tergite with one or more pairs of bristles proximad of the usual apical central pair, or with a complete apical series of long bristles. 18a
- First visible abdominal tergite with at most four apical central bristles, none proximad of these, and the apical series never complete and uniform. 19
- 18a. Frons of the male over one-fourth of the head width; fore tarsi of the female not dilated, or if so then the apical series of bristles on the first visible abdominal tergite is complete. *Plethochastigera*, n.gen. 18b
- Frons of the male very much less at its narrowest point than one-fifth of the head width; first visible abdominal tergite without a complete apical series of strong bristles. 18b
- 18b. Scutellum with at least 8 strong marginal bristles; face not foveolate. *Platytachina*, n.gen. 18c
- Scutellum with 6 marginal bristles. 18c
- 18c. Face not at all bifoveolate; postsutural dorsocentral bristles in 4 pairs. *Veluta*, n.gen. 32
- Face rather noticeably bifoveolate; postsutural dorso-centrals in 3 pairs. 32
19. Face deeply sunken, with two deep foveae in the depressed part that are separated by a slender vertical carina no part of which is visible above the edge of the parafacial in profile; parafacials about as wide as eye in profile; gena over half as high as eye, the raised haired posterior part terminating in an oblique line in front and never extending midway to the vibrissal angle; frons of male never less than one-fifth of the head width. 20
- Face not deeply sunken nor carinate as above, if so then the carina is visible beyond the parafacial in profile or parafacial at its narrowest point in profile is not half as wide as the eye at middle; gena not, or very little, over half as high as eye. 30

20. Large species, not less than 15 mm. in length, very stout, the abdomen broadly ovate and with a complete apical transverse series of long erect bristles on second and third visible tergites in both sexes and an additional one on fourth in the male, no discal bristles present, the bristles mainly black at bases and orange-yellow at apices; pleura with long fine pale hairs that are somewhat crinkly. *Hystericina*, Malloch
- Species generally much smaller and not as robust, with the abdomen differently bristled and the bristles black; pleura usually dark haired, the hairs stronger and straight. 21
21. No one bristle on the vibrissal angle more conspicuously outstanding than the others, the epistomal margin about the same level as lower genal margin. 22
- One bristle on the vibrissal angle much longer and stronger than any of the others; palpi longer than the entire antenna in both sexes, or if not then the proboscis exceptionally long and slender. 23
22. Palpi not longer than the third antennal segment; proclinate outer orbital bristles lacking on the male. *Avibrissina*, Malloch
- Palpi longer than entire antennae; outer proclinate orbitals present in the male. *Avibrissia*, Malloch
23. Scutellum with stiff short hairs on ventral surface to its apex. 24
- Scutellum bare at apex of ventral surface 25
24. Three bristles on the presutural lateral area of the mesonotum; no costal spine at apex of the subcostal vein. *Neoerythronychia*, Malloch
- Two bristles on the presutural area of the mesonotum; costa with a distinct bristle or spine at apex of the subcostal vein. *Erythronychia*, Brauer and Bergenstamm
25. Infrascapular hairs lacking; hypopygium of the male with a pair of slender slightly spatulate densely haired processes that usually project well beyond the apex of the abdomen. *Asetulia*, n.gen.
- Infrascapular hairs present; hypopygium of male not as above. 26
26. Apical section of the proboscis slender and distinctly longer than height of the head; second antennal segment short, flattened and densely short haired above. 27
- Apical section of the proboscis not particularly slender and not longer than height of the head; if slightly elongated the second antennal segment normal. 28
27. Palpi longer than antennae. *Xenorhynchia*, n.gen.
- Palpi not much longer than thickness of base of apical section of the proboscis. *Prosenosoma*, n.gen.
28. Parafacial at lower level of eye about as wide as eye at middle; gena below eye almost or quite as high as eye; arista thickened to beyond middle. 29
- Parafacial at lower level of eye not nearly as wide as eye; gena below eye not nearly as high as eye; arista not thickened to middle. 30
29. Vibrissae separated by about the width of the third antennal segment, the area between them with a central flat strip that is distinctly higher than wide, the facial carina sometimes slightly tumid at its lower extremity; third antennal segment rarely over twice as long as wide, sometimes in male quite wide, the sexes showing considerable difference in the comparative width and length of the segment. *Peremptor*, Hutton

Vibrissae usually more widely separated, the area between them without a pronounced flat strip, usually the facial depression begins just above the epistome and when it does not, then the flat part is not higher than wide; third antennal segment slender, always over twice as long as wide, not markedly wider in males than in females. . .

Procissio, Hutton

30. Blue or glossy black species, with the frons in the male and female about one-third of the head width, and the epistome not at all produced, the face almost vertical; abdomen without discal bristles on first and second visible tergites in either sex; outer cross vein not over one-fourth as far from bend of fourth as from inner cross vein. . .

Occisor, Hutton

Species not blue or glossy black, or if the abdomen is blue, then the frons of the male is very much less than one-third of the head width at its narrowest point, the abdomen is differently bristled, and the outer cross vein of the wing is about one-third as far from bend of fourth as from inner cross vein. . .

31

31. Apical pair of scutellar bristles reduced to minute fine hairs, only 4 long marginal bristles present, the disc usually with 4 almost erect fine bristles and numerous decumbent hairs; frons of the male about one-fourth of the head width, each orbit with one long upper bristle curved outward over eye and the usual series of inner marginal incurved bristles, that of the female about one-third of the head width, each orbit with the upper outwardly curved bristle and in front of it an outer proclinate bristle; first posterior cell of the wing open; face almost flat, the epistome very slightly produced; parafacial with microscopic hairs on less than the upper half, not as wide at narrowest point as the third antennal segment; abdomen with apical central bristles on all tergites and discals on second to fourth. . .

Altaia, n.gen.

Apical pair of scutellar bristles present, sometimes very much shorter than the subapical pair; other characters not as above in combination. . .

32

32. Scutellum with at least 8 strong marginal bristles; abdomen broadly ovate; postsutural dorsocentrals four pairs; fifth visible abdominal tergite in male consisting of a narrow transverse strip that is four or more times as wide as its length in centre and furnished with numerous bristles and long hairs (Fig. 47); face not bifoveolate. . .

Platytachina, n.gen.

Scutellum with six or eight strong marginal bristles, and in general as *Platytachina*, but the fifth abdominal tergite is much longer, less than four times as wide as long, with the suture between it and the sixth merely indicated by a depression, and the face is distinctly though not deeply bifoveolate. . .

Neotachina, n.gen.

Scutellum with six strong marginal bristles, if with eight then the fifth abdominal tergite in the male is entirely or almost entirely concealed (Fig. 61). . .

33

33. Head at vibrissal angle not as long as at level of bases of antennae; face with two shallow foveae separated by a linear carina; abdomen with a pair of well developed apical central bristles on first and second visible tergites and a similar pair of discals on second and third. . .

Macquartia,

Head at vibrissal angle longer than at bases of antennae. . .

Robineau-Desvoidy

34

34. Abdomen in both sexes broadly ovate, not over 1.5 times as long as wide; postsutural dorsocentrals 4 pairs; first posterior cell of the wing quite widely open. *Neotachina*, n.gen.
- Abdomen narrowly ovate, usually fully twice as long as wide; postsutural dorsocentrals 3 pairs; first posterior cell of wing narrowly open, sometimes closed in margin or even with a short petiole. 35
35. Parafacial much wider than the third antennal segment; face slightly bifoveolate; frons of male very much narrower than that of female, without proclinate outer orbital bristles; each process of fifth sternite of male with a deep central incision. *Phaoniella*, n.gen.
- Parafacial not wider than the third antennal segment except near its upper extremity; face not at all bifoveolate; processes of fifth sternite of male not excised. 35a
- 35a. Second aristal segment more than twice as long as thick; frons of male and female equally wide, at vertex at least one-fourth of the head width; parafacial with a few setulose hairs on upper extremity below the anterior frontal bristle. *Campylia*, n.gen.
- Second aristal segment not twice as long as thick; frons of male except in one species not as wide as above; parafacial with some minute hairs from upper extremity to near the level of the insertion of the arista, the latter sometimes farther from base of the third segment of the antenna than usual. *Zealandotachina*, n.gen.
36. Infrascapular hairs lacking. *Asetulia*, n.gen.
- Infrascapular hairs present. 37
37. Lower squama narrower than usual, its inner edge rounded at apex and not touching lateral edge of the scutellum; parafacial in profile at middle not over half as wide as third antennal segment; arista with the second segment not longer than thick, not angulated at junction of second and third segments. 38
- Lower squama of the usual width, widened behind, with a slight angle at apex of inner edge and in part touching the lateral edge of the scutellum; parafacial rarely narrower than third antennal segment. 39
38. Frons of male narrow, in front of ocelli not wider than the third antennal segment, without proclinate outer orbitals, that of the female about one-third of the head width, the interfrontalia at middle much narrower than either orbit at same point. *Tryptherina*, n.gen.
- Frons of male and female about one-third of the head width and with proclinate outer orbital bristles, the interfrontalia of the female very much wider than the orbits at centre. *Neotrypthera*, n.gen.

39. Third antennal segment much wider than parafacial at middle, especially in the male, generally wider at apex than in centre; second segment of the arista three or four times as long as thick, a little shorter in the female, usually more or less distinctly geniculated at junction of second and third segments; frons of male about one-third of the head width, with the upper bristle on each orbit curved outward over the eye and no proclinate outer bristles on the upper half, that of the female of the same width, with two outwardly curved upper and one proclinate lower bristles; fore tarsi of the female slightly widened. *Campylia*, n.gen.

Third antennal segment rarely noticeably wider than the parafacial at middle in profile, and almost invariably as wide at middle as near apex; second segment of the arista not twice as long as thick. 40

40. Fourth wing vein exceptionally looped into the cell just above the preapical angle, the latter almost loop-like; frons of the male about one-fourth of the head width, without proclinate outer orbital bristles, that of the female about one-third of the head width and with the usual outer proclinate orbital bristles. *Graphotachina*, n.gen.

Fourth wing vein not or but slightly bent into the cell above the preapical angle; frons of the male less than one-fifth of the head width. 41

41. Fore tarsal claws of the male abnormal, either appearing thickened to near apices because of the presence of dense short black pile, or asymmetrical, the outer one of each pair peculiarly distorted and thickened near apex; stout species with broadly ovate abdomen; postsutural dorsocentrals in four pairs; frons of the male narrow, never over one-fifth of the head width at vertex, without outer proclinate orbital bristles, that of the female not over one-fourth of the head width at vertex, widened in front and with the usual outer proclinate orbital bristles. *Perrissina*, n.gen.

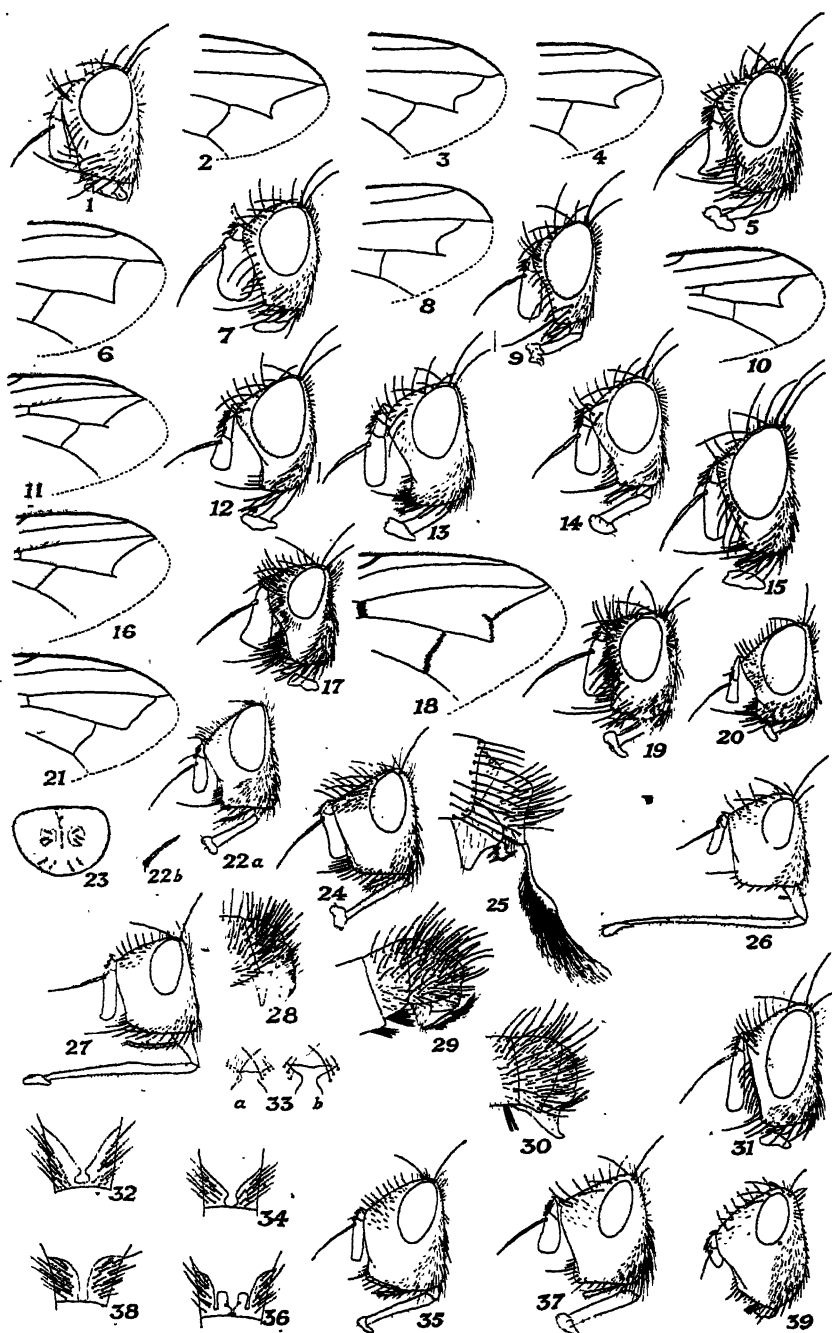
Fore tarsal claws of the male normal, neither with dense pile causing them to appear thickened to near apices, nor asymmetrical; rather slender species, the abdomen never broadly ovate; postsutural dorsocentrals in three pairs; frons of male variable, never with proclinate outer orbital bristles, that of the female usually at least one-fourth of the head width at vertex and with the usual proclinate outer orbitals. 42

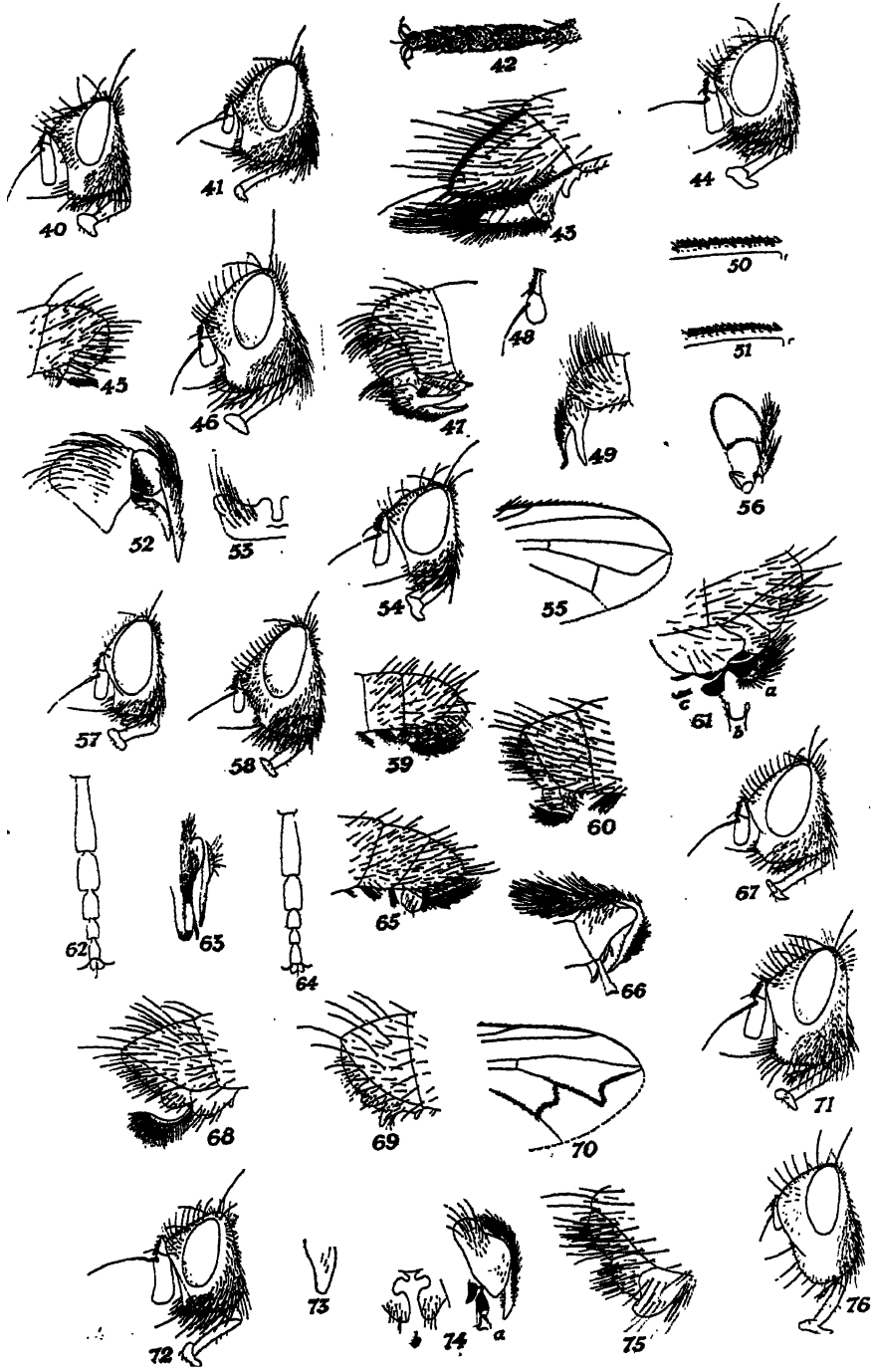
42. Mid femur with a single exceptionally strong bristle near base on the posteroventral surface; eyes nude, at most one or two extremely minute scattered hairs present; apical scutellar bristles variable, sometimes microscopic. *Medinella*, n.gen.

Mid femur with the usual series of posteroventral bristles on basal half or more, no one of which is outstanding; eyes quite densely or long haired; apical scutellar bristles about half as long as the next pair. *Zealandotachina*, n.gen.

A CHECK LIST OF THE TACHINIDAE OF NEW ZEALAND.

- Huttonobesseria*, Curran.
verecunda (Hutton).
Eviobrisa, Rondani.
huttoni, Malloch.
Hyalomyia, Robineau-Desvoidy.
(Campbellia, Miller.)
campbelli (Miller).
cockaynei (Miller).
lanoifer, Malloch.
Calcageria, Curran.
incidens, Curran.
var. *nuda*, Malloch.
varians, Malloch.
Uclesiella, Malloch.
irregularis, Malloch.
Calcager, Hutton.
apertum, Hutton.
dubium, Malloch.
Plagiomyia, Curran.
turbidum (Hutton).
achaeta, Malloch.
longipes, Malloch.
alticeps, Malloch.
longicornis, Malloch.
Calotachina, Malloch.
tricolor, Malloch.
Genotrichia, Malloch.
tonnoiri, Malloch.
minor, Malloch.
Wattia, Malloch.
ferruginea, Malloch.
petiolata, Malloch.
sessilis, Malloch.
Arthuria, Malloch.
dimorpha, Malloch.
Microhystiricia, Malloch.
gourlayi, Malloch.
Hexamera, Brauer and Bergenstamm.
signata (Walker).
huttoni, Malloch.
Cerosomyia, Hutton.
usitata, Hutton.
syn. *oratus* Walker?
clathrata Nowicki?
efferata, Hutton.
fulvipes, Hutton.
recta, Hutton.
aurea, Hutton.
functa, Hutton.
inconspicua, Hutton.
atrox, Hutton.
syn. *perniciosa*, Hutton?
casta, Hutton.
Eugycera, Malloch.
poliitiventris, Malloch.
var. *setosus*, Malloch.
monticola, Malloch.
pellipes, Malloch.
kumarensis (Miller).
syn. *vittata*, Curran.
modica (Hutton).
syn. *parida*, Hutton.
Procissio, Hutton.
cana, Hutton.
var. *valida*, Hutton.
syn. *montana*, Hutton.
lateralis, Malloch.
albiceps, Malloch.
var. *varians*, Malloch.
milleri, Malloch.
Cerosomyia, Hutton.
exitosa, Hutton.
nefaria, Hutton.
nyctemeriana, Hudson.
marginata, Hutton.
? *brouni*, Hutton.
Occisor, Hutton.
versutus, Hutton.
inscitus, Hutton.
atratus, Malloch.
Hystiricina, Malloch.
lupina (Swederus).
Veluta, Malloch.
albicineta, Malloch.
Altaia, Malloch.
geniculata, Malloch.
Macquartia, Robineau-Desvoidy.
vezata, Hutton.
flavohirta, Malloch.
nigrihirta, Malloch.
claripennis, Malloch.
Phaoniciella, Malloch.
bifida, Malloch.
Platytachina, Malloch.
major, Malloch.
latifrons, Malloch.
atricornis, Malloch.
difficilis, Malloch.
angustifrons, Malloch.
Zealandotachina, Malloch.
subtilis (Hutton).
nigrifemorata, Malloch.
varipes, Malloch.
var. *varipes*, Malloch.
var. *fumata*, Malloch.
var. *fuscata*, Malloch.
var. *strigipes*, Malloch.
var. *lata*, Malloch.
setigera, Malloch.
quadriseta, Malloch.
infusata, Malloch.
quadrivittata, Malloch.
lamellata, Malloch.
tenuis, Malloch.
latifrons, Malloch.
Subgen. *Calosia*, Malloch.
binigra, Malloch.





- Heteria*, Malloch.
appendiculata, Malloch.
punctigera, Malloch.
extensa, Malloch.
plebeia, Malloch.
flavibasis, Malloch.
atripes, Malloch.
 (*Microphthalma*, Macquart).
 (*michiganensis*, Townsend).
- Plethochaetigera*, Malloch.
fennicki, Malloch.
setiventris, Malloch.
isolata, Malloch.
 Subgen. *Chaetopletha*, Malloch.
centralis, Malloch.
- Avibrissina*, Malloch.
brevipalpis, Malloch.
laticornis, Malloch.
- Avibrissia*, Malloch.
longirostris, Malloch.
- Erythronychia*, Brauer and
 Bergenstamm.
australiensis (Schiner).
aliena, Malloch.
humeralis (Hutton).
velutina, Malloch.
minor, Malloch.
hirticeps, Malloch.
aperta, Malloch.
princeps (Curran).
defecta, Malloch.
grisea, Malloch.
- Neoeerythronychia*, Malloch.
hirta, Malloch.
- Peremptor*, Hutton.
egmonti, Hutton.
- Xenorhynchia*, Malloch.
peeli, Malloch.
- Prosenosoma*, Malloch.
greyi, Malloch.
- Asetulia*, Malloch.
nigropolita, Malloch.
- Graphotachina*, Malloch.
sinuata, Malloch.
- Campylia*, Malloch.
temerarium (Hutton).
nudarium, Malloch.
- Perrissina*, Malloch.
crocea, Malloch.
albiceps, Malloch.
brunniceps, Malloch.
xanthopyga, Malloch.
variceps, Malloch.
- Neotryphera*, Malloch.
atra, Malloch.
- Trypherina*, Malloch.
grisea, Malloch.
- Medinella*, Malloch.
nigrifemorata, Malloch.
flavofemorata, Malloch.
albifrons, Malloch.
varipes, Malloch.
- Truphia*, Malloch.
grisea, Malloch.
- Neotachina*, Malloch.
obtusa, Malloch.
angusticornis, Malloch.
laticornis, Malloch.
 Subgen. *Tachineo*, Malloch.
clarki (Hutton).
depressa, Malloch.

PART IX.

FAMILY MUSCIDAE.

SUBFAMILY PHAONIINAE.

I have before me two species of a genus that is rather difficult to place in any known subfamily, but which I have decided on the basis of all its characters is more allied to *Phaoniinae* than to *Coenosiinae*. I have for a number of years been compiling a generic key to the family Muscidae and amongst the most difficult of the tasks in that connection is that of differentiating the subfamilies. Finally I have determined that though the segregation of *Coenosiinae* is difficult and rather hard to maintain on the basis of available characters, one can distinguish all the members of the group from any in *Phaoniinae* by the possession of but one recurved bristle near the upper extremity of each orbit, and the hind tibial armature,

which never consists of more than one bristle on the anterodorsal, anteroventral, and posteroventral surfaces. If there are two postero-dorsal and anterodorsal bristles on the hind tibia I place the species in *Phaoniinae*. In the present genus there is but one recurved bristle on the upper extremity of each frontal orbit, but the hind tibia has two anterodorsal and posterodorsal bristles. In addition to this last character the three sternopleural bristles are not in an almost equilateral triangle, there are two pairs of presutural dorsocentral bristles present on the mesonotum, and the sixth wing vein, though incomplete, extends over two-thirds of the distance to the wing margin, none of which characters are in conformity with the general rule in *Coenosiinae*. It may be noted here that so far I have seen no typical representative of this subfamily from New Zealand.

I propose for this genus the name *Paracoenosia* with the genotype, *P. tonnoiri*.

GENUS PARACOENOSIA, novum.

The two species now before me may be distinguished as below:—

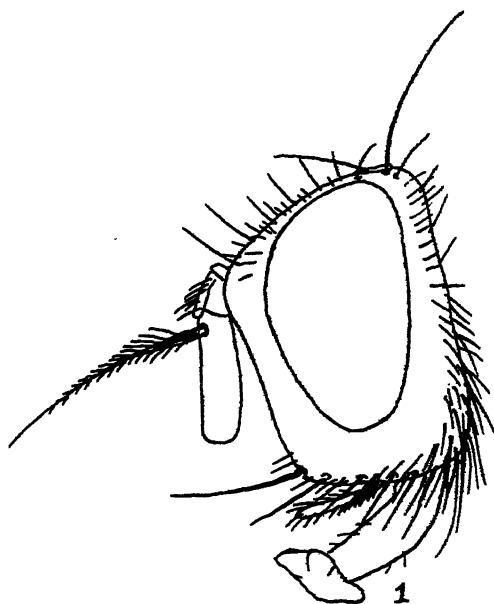
- A. Antennae entirely ferruginous yellow. .. *tonnoiri*, n.sp.
- AA. Antennae with the third segment fuscous .. *bicolor*, n.sp.

Paracoenosia tonnoiri, n.sp.

Male, Female. A ferruginous to tawny yellow species, with the antennae and palpi entirely pale, the aristae fuscous except the basal two segments, the abdomen broadly brown on the dorsum, darker in the male than in the female, and with traces of a central line and a pair of faint darker spots on each tergite in the former, the sides of the tergites with greyish white dust, most distinct in the male. Head with yellow dust on frontal orbits and triangle and the occiput entirely yellow dusted, the dust becoming paler from upper part of face to epistome, almost white below and on the parafacials and genae; interfrontalia reddish yellow. Mesonotum without vittae, the entire thorax dull. Legs concolorous with thorax. Wings tinged with brownish yellow, especially anteriorly, the veins yellowish brown; squamae paler than wings; halteres brownish yellow.

Frons at vertex in male less than, in female more than, one-fourth of the head width, and much longer than wide, the orbits narrow, the triangle slender and continued to beyond middle. Vertex with the inner pair of bristles long in both sexes, the outer pair almost undeveloped in the male, small in the female; ocellars well developed, proclinate and divergent; postverticals widely divergent, smaller than the ocellars, and subequal to the incurved pair lower on occiput; each orbit with a very short outwardly and slightly backwardly directed bristle almost at level of the anterior ocellus, and about half a dozen strong incurved inner marginal bristles and

some much shorter setulae and short hairs. Profile as text-figure 1; longest hairs on the arista barely twice as long as its basal diameter. Eyes bare. Proboscis stout.



TEXT-FIG. 1.—*Paracoenosia tonnoiri*, head of ♂ in profile.

Mesonotum with 2 + 3 pairs of strong dorsocentrals, the prealar lacking, no presutural acrostichals, and the prescutellar pair present or lacking; sternopleurals usually three, occasionally four, and some setulose hairs between them, scutellum with short decumbent discal hairs and four strong and usually four much shorter and weaker bristles on the margin. The lower stigmal bristle is represented by a weak upwardly curved setula. Mesonotum with numerous very short black hairs.

Legs moderately long, the femora stout. Fore femur with a series of setulae on anteroventral surface, an irregular series of bristles and setulae on posteroventral surface, and some long bristles on the posterodorsal and posterior surfaces; mid femur with an irregular series of long and short bristles on the anteroventral surface and a similar but closer series of longer bristles and stouter spinules on the posteroventral surface, the latter more than uniseriate apically; hind femur with the same irregular strong armature of the mid femur, but the bristles more numerous; fore tibia with a posterior bristle beyond middle, the apical ventral bristle not longer than the tibial diameter; mid tibia with a submedian posterior bristle and three apical bristles below that are stronger and longer than the one at apex of ventral surface of fore tibia; hind tibia with two anterodorsal and two posterodorsal bristles, no anteroventral, the preapical dorsal and preapical anterodorsal bristles not

transverse in position, the latter the shorter, and the apical antero-ventral longer than the tibial diameter and straight. Tarsi normal, claws and pulvilli a little larger in male than in female.

Wings of moderate size, about as long as thorax and abdomen combined, rounded at apex. Inner cross vein close to middle of discal cell and just beyond level of apex of first vein, outer cross vein about half its own length from apex of fifth vein, apical sections of third and fourth veins curved slightly downward, the first posterior cell not narrowed at apex, ultimate and penultimate sections of fourth vein subequal in length; costal thorn minute.

Abdomen of male narrowly cylindrical, of female rather broadly ovate. First visible tergite with a series of bristles on sides at middle and one or two at apex on sides, the others with lateral apical bristles except third and fourth in the male, which have an almost complete apical series; fifth tergite in male short and bare, sixth in same sex with a number of discal bristles. Hypopygium of male not very large, the processes of the fifth sternite broad, rounded at apices, where they are bare, and with a number of discal bristles.

Lower squama over twice as large as upper one, not very wide, rounded at apex.

Length, 8-9.5 mm.

Holotype, Male, allotype, and 1 paratype, Aniseed Valley, 1-4.xii.23 (A. L. Tonnoir); male paratype, Cobb Valley, 10.xii.22 (A. Philpott).

Named in honour of the collector of the type specimen.

Paracoenosia bicolor, n.sp.

Very similar to the genotype, of which in fact it may prove to be merely a variety. There are no intermediates in my material, all the specimens of both sexes in *tonnoiri* having the antennae entirely ferruginous, and all in *bicolor* having the third antennal segment entirely fuscous or almost black. In other respects the two are almost identical, though I have not investigated the structures of the hypopygia of the males, in which there may be differentiating features.

Length, 7.5-8 mm.

Holotype, Male, Kumara, 3.xi.29 (J. W. Campbell); allotype, Waiho, 24.i.22 (A. L. Tonnoir); paratypes, 2 females from Grey-mouth (Osten-Sacken coll., Berlin-Dahlem).

The last listed specimens were no doubt sent many years ago to Baron Osten-Sacken by either Hutton or some one of the older collectors and were never reported upon, passing into the collection of the Deutsches Entomologisches Institut, from whence they were sent to me by my friend Dr. Walther Horn for identification some time ago.

EXPLANATION OF FIGURES.

- FIG. 1.—*Wattia ferruginea*, head of female in profile.
 FIG. 2.—*Wattia ferruginea*, apex of wing of female.
 FIG. 3.—*Wattia petiolata*, apex of wing of female.
 FIG. 4.—*Wattia sessilis*, apex of wing of female.
 FIG. 5.—*Genotrichia tonnoiri*, head of male in profile.
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An Outline of the Vegetation and Flora of the Tararua Mountains.

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INTRODUCTION.

History.

THE earliest records on the botany of the Tararua Mountains were made by Buchanan (1874). The first botanist to ascend the mountains was Cockayne (1907), but he published merely a few new records of species. Petrie (1908) was the first to make notes on the vegetation along the route to Mount Hector. He was followed by Aston (1910), who climbed Mt. Holdsworth and a few other places in addition. Aston made some further references to the Tararua plants in his list of species in the Wellington province (1911), and he also published a list of plants of C. Turakirae (1912). Nothing has been published since, except references to the collectors in Cheeseman's *Manual* (1925) and a few remarks by Cockayne (1926, 1928, 1928a) on ecology.

The present authors commenced their investigations at a time when the late Dr. L. Cockayne was still active in the field of botany. It is due very largely to his influence and every possible encouragement that the investigations were undertaken and the energies of the independent investigators ultimately combined in the present paper. The authors are also deeply indebted to Dr. H. H. Allan for his interest in this work, and to many of their tramping friends in whose company the authors have made pleasant trips into some very difficult country.

The aim of this paper is to give an outline of the primitive, or as nearly such as it is preserved this day, plant covering of the mountains, especial attention being paid to the plant distribution, and an attempt being made to give a critically revised and annotated list of species. Zotov and Elder have traversed practically every ridge and river shown on the map, and Beddie has explored very thoroughly the southern portion, especially the area with Mount Matthews as centre.

Geology.

The Tararua Mountains represent that position of the main axis of New Zealand mountains running in N.N.E.-S.S.W. direction, which extends from the Manawatu Gorge to Cape Turakirae, being some 150 km. long and 25 km. wide. On the east side they are bounded by the Wairarapa Plains, which rise to about 300 m. towards the middle of the mountains and about the low hills of the main divide, descending plains continuing northward of this. On the west side they are bounded by the Tasman Sea and the Manawatu Plains, which for the most part lie well below 100 m. at the foothills. The hills above the Manawatu Gorge are only about 450 m. high. From here they rise gradually towards the middle until they are about 1500 m., with Mount Arête, 1504 m., in the centre of the watershed, and Mitre, 1570 m., which is off the main range, the highest peak. Continuing southward, the main range often drops well below 1200 m. until Mount Hector, 1529 m., a secondary centre of the system, is reached. From here the range rapidly drops to below 500 m., at Rimutaka Saddle, and then continues under the name of Rimutaka Range, gradually rising towards Cook Strait with Mount Matthews, 939 m., the highest peak overlooking Palliser Bay.

The mountains are built almost entirely of non-fossiliferous Trias-Jura sandstone (mostly submetamorphic greywacke) with some shales. There are small patches of younger limestone at the foot of the hills at Manawatu Gorge and along the plains on the east side together with some calcareous mudstone. The extent of these is, however, almost insignificant. The apparently recently elevated range in the vicinity of the Cook Strait is composed largely of black, slaty shales which crumble readily and run into extensive screes. The mountains, it would appear, were generally elevated in recent geological times some 600 m. with further upward warping in their middle part. Throughout there are still numerous places of uneroded tableland from which streams often plunge hundreds of metres into deep gorges. Valleys with more or less extensive river flats are not uncommon. Narrow rugged ridges as well as more gentle ones with numerous tarns are frequent, while many flat-topped summits are boggy.

Climate.

Tararua Mountains are subject to intense moisture-saturated N.W. winds. On the average, for about five days the wind blows from N.W. or N., on three days from S.E. or S. The winds are more evenly divided in July, while in January N.W. wind is more than twice as frequent as S.E. The average velocity of S.E. winds is much lower than that of N.W. The lowest mean monthly velocity at Wellington occurs in July, about 4.3 m.p.s., and the highest in October, about 6.2 m.p.s. The velocities must, of course, be much higher in the mountains. Kidson (1930) indicates on his maps that at about 1200 m. the average number of rainy days is about 200. The rainfall at this elevation exceeds 250 cm., while in the neighbourhood of 800 m. it is only 100 cm., the rainfall becoming more frequent and heavier with increasing altitude. It is fairly evenly

distributed throughout the year. Occasionally snow falls as low down as sea-level. Above 1200 m. it persists almost continuously for about five months, from June till November. At these heights frosts occur even in the warmest parts of summer. The coldest month is July with mean sea-level temperature about 8.5° C., and the warmest, January with mean sea-level temperature about 16.7° C. The crests of the ranges are fog-bound for some 200 days a year. For two years careful records were kept, with the assistance of Mr. A. J. Hilkie, of Wellington, on the fog conditions as they could be observed from Wellington and Palmerston North. The following table shows the weather prevailing on the high crests of the central portion of the ranges during the 1932-33 season. Any day with more than 4 hours of clear weather is shown as a fine day (C), days with continuous heavy fog are marked (H), while days with intermediate conditions are marked (L). That direction of wind which prevailed during the greater part of a day is recorded as if it actually prevailed during the whole day. Calm days are credited with the wind that prevailed on days preceding them. Calm days, or days with changeable winds, however, are of too rare occurrence to affect the general accuracy of the table.

The seasons preceding and following 1932-33 indicate that the weather during the period was exceptionally fine. Thus, in 1931, there were only forty-six days with fine weather on the crests and about fifty-five in 1935. No accurate record was kept for lower ranges at either end of the mountains, but continuous observations indicate that the foggy conditions prevail there as frequently as in the higher central ranges. The southern end tends to be covered with fog more frequently during S. or S.E. winds. The same is the case with the hills north of Mount Bruce.

Man's Influence.

Extensive areas on the Tararua Mountains below 600 m. in many places have been converted into pastures or, as is the case in many places where man was not sufficiently judicious, it is laid waste, whole hillsides running into slips. Timber milling is in progress in a number of places. In others stock has full access to the otherwise untouched forest. The vegetation of these places was largely reconstructed from scattered, more or less well-preserved, remnants or else left as gaps, probably never to be filled. This particularly applies to the low range branching towards Wellington.

The vegetation, where it has not been touched by man, is remarkably free from introduced species. Almost the only places subject to invasion are river-beds where *Trifolium repens*, *Holcus lanatus*, *Dactylis glomerata*, *Nasturtium officinale*, *Agrostis* spp. are of common occurrence. Most of the other species of nearby cultivated areas also occur here. None are found in the forest except perhaps occasionally along regularly used tracks and about mountain huts. *There is only one species, Hypochaeris radicata, found above the forest line, but even this seems to be able to compete against native plants only with the help of deer.*

WEATHER ON NORTHERN TARANUS.

Wind Direction	N		NW		W		SW		S		SE		E		NE		Total	
	C	L	H	C	L	H	C	L	H	C	L	H	C	L	H	C	L	H
1882																		
March			2	1												14	11	6
April			3	13	1											13	1	16
May				4	1											6	14	11
June			1	23		1										2	4	24
July			2	10												5	6	20
August			1	10												5	7	16
September			1	3	2		1									5	8	17
October			1	3	1	1	1									5	8	13
November			1	7	1	1										5	9	16
December			2	6	1	3										7	13	11
1883																		
January			4	13												8	14	9
February			2	5	1											8	7	18
Total	2	8	19	44	118	3	8	4	1	1	1	4	11	8	4	1	4	81
Total	11		181		15		8		23		114		9		9		365	
South Taranus	16	12	7	22	38	104	3	2	2	22	10	49	2	4	5	5	80	215

Introduced animals exert much greater influence on the native vegetation than do plants. The Tararuas, once devoid of grazing and browsing animals, are now swarming with them. Goats are numerous in many places and are particularly abundant in the Rimutaka Ranges. Opossum are plentiful throughout. Deer and pigs infest the country, the former being especially plentiful at higher elevations, the latter at the lower. Just how much damage these animals cause is difficult to estimate in figures, but the evidence of the destruction they bring about with them is abundant everywhere. The ground cover of forest is considerably altered and even completely destroyed in many places. The trampling and consolidation of soil is to be seen everywhere. Extensive areas above the forest suffer the same fate. No less significant is the spread of stoats and weasels as well as rats and mice, which prey on bird life. As the consequence of this follows the abnormal increase of insects with disastrous effect on plants.

ECOLOGY OF THE TARARUA MOUNTAINS.

V. D. Zotov.

Relation to Rock.

The earliest attempt to correlate environment with the plant cover of the Tararua Mountains was made by J. Buchanan (1874). He attached particular importance to the influence of various rock formations on their plant cover. In fact, he went so far as to say that the underlying rock can be recognised by the plants growing on it. This appears to be wholly unfounded. Though a thorough study of the distribution of various rocks and plant communities may in future reveal this relationship, there is only one such case definitely known at present. This is that *Gnaphalium subrigidum* is restricted to the calcareous rocks to be found in the valleys along the foothills in the north. The distribution of all more physiognomic species is certainly perfectly explicable by climatic conditions alone.

Relation to Temperature.

In the study of the vegetation of a large area it is convenient to subdivide the latter into a number of smaller units determined by the more important environmental factors. Of these on the Tararuas, as in most other mountainous places, temperature is the most important single variable factor to consider. Next come rainfall and others associated with it. Since the Tararuas extend only some 150 km. from north to south, the latitudinal variation cannot be significant. Further, according to Kidson (1931), the isotherms with slight gradient run more or less parallel to the axis of the mountains. The altitudinal variation of 5° C. per 100 m. over 1500 m. on the other hand is appreciable. Whatever the manner in which temperature affects the plants, the effects themselves can be readily studied, for example, the altitudinal delimitation of the range of species. This in its turn gives the means of delimiting botanical belts, which may be termed *temperature belts* as distinct from those determined by other factors. On the Tararuas the belts are as shown in the table below. The principles on which modification of terminology is based are discussed by the author in "Some Correlations Between

Vegetation and Climate in New Zealand" (1938). L. Cockayne's (1928) terminology adapted especially for the Tararua is also shown for comparison.

Cockayne's Description of Belts.	Altitude in m.	Modified Description of Belts.	
Alpine	1800	Upper (absent)	} Warm subpolar
	1500	Lower	
	1200		
Subalpine { Upper	900	Upper	} Cold temperate
Subalpine { Lower	600	Lower	
Montane	300	Upper .. .	
Lowland	0	Lower .. .	Warm temperate

Thus on the Tararua there are three primary belts: *Warm Temperate* from sea level to 600 m., *Cold Temperate* from 600 m. to 1200 m., and *Warm Subpolar* from 1200 m. to the highest peaks. Each of these can be satisfactorily subdivided into *upper* and *lower* belts of 300 m. each. There are a number of species which extend through several belts. Many species also have an ill-defined lower range limit. The upper limit, however, in most cases is very sharp. The disappearance not only of a species, but of whole groups of them is generally complete well within 25 m. of an arbitrary limit line.

The characteristic species of the warm temperate belt are: *Beilschmiedia tawa*, *Hedycarya arborea*, *Knightia excelsa*, *Melicytus ramiflorus*, *Rhipogonum scandens*, *Pseudowintera axillaris*, *Nothopanax arboreum*, *Freycinetia Banksii*, *Clematis indivisa*, *Pittosporum Edgerleyi*, *Nothofagus truncata*, *N. Solandri*, *Mida salicifolia*, *Cyathodes acerosa*, *Metrosideros robusta*, *M. scandens*, *Astelia Solandri*, *Earina autumnalis*, *Dendrobium Cunninghamii*, *Uncinia uncinata*, *Isolepis cernua*, *Cyathea dealbata*, *Polystichum Richardi*, *Danthonia antarctica* *Cheesemanii*. All these species disappear nearly at the same altitude.

The following characteristic species of the cold temperate belt do not, as a rule, descend into the lower belt: *Pseudowintera colorata*, *Coprosma foetidissima*, *Olearia lacunosa*, *O. Colensoi*, *O. arborescens*, *Senecio elaeagnifolius*, *Dracophyllum Urvilleanum*, *Pittosporum rigidum*, *Nothopanax Colensoi*, *Gahnia pauciflora*, *Danthonia Cunninghamii*, *Astelia nervosa*, *Uncinia filiformis*, *Isolepis aucklandicus*, *Libertia pulchella*, *Nertera setulosa*, *N. dichondraefolia*.

None of the above species, nor indeed any of the other woody species of the temperate belt, with the exception of *Olearia Colensoi*.

occurs above this belt. *O. Colensoi*, however, often extends well into the lower warm subpolar belt. *Libertia pulchella* and *Uncinia filiformis* are restricted to the lower cold temperate. *Nothofagus Menziesii* is one of the most characteristic species of the cold temperate, but in fairly dry places, where plenty of light reaches the ground, it occurs in abundance as low down as the upper warm temperate. *Nothofagus fusca* ranges generally from lower cold temperate to upper warm temperate. A few species including *Weinmannia racemosa*, *Coprosma australis*, *Aristotelia racemosa*, *Rubus cissoides*, *Dacrydium cupressinum*, *Fuchsia excorticata* range from the lower cold temperate to the sea-level.

Of the higher belts only the lower warm subpolar is represented on the Tararuas. The following species are characteristic of this belt: *Dracophyllum rosmarinifolium*, *Senecio Bidwillii*, *Hebe Astoni*, *Raoulia rubra*, *R. grandiflora*, *Phyllachne Colensoi*, *Celmisia hieracifolia*, *Danthonia flavescentis*, *D. —*, *Astelia Cockaynei*, *Celmisia spectabilis*, *Anisotome dissecta*, and *A. aromatica* are often the dominant species, particularly the first three. *Aciphylla Colensoi* *conspicua*, *Ranunculus geraniifolius*, and many others are plentiful.

Relation to Sunshine.

The temperature belts as just described must be distinguished from vegetational formations such as scrub and forest. The latter may or may not coincide with the former and since they are often characterised by a single dominant species, they may depend on any of the numerous controlling environmental factors. The dominant species of the scrub formation on the Tararuas is usually *Olearia Colensoi*, while of the forest of the higher altitudes it is almost exclusively *Nothofagus Menziesii*. Since *O. Colensoi* penetrates far down into the forest, it is obvious that this timber line depends entirely on the presence or absence of *N. Menziesii*.

On the Tararuas, particularly on their western side, the timber line is very irregular, varying from 1200 m. to 500 m. The lowest point to which the timber line drops occurs in the neighbourhood of Baber's Saddle, about 30 km. south of the Manawatu Gorge. Here the scrub formation, which includes some *Weinmannia racemosa*, *Podocarpus Hallii*, and *Phyllocladus alpinus* reduced to scrubby state, is to be found alongside the forest of warm temperate belt. It may be noted that the variation in altitude of the timber line is in no way connected with altitudinal range of the temperature belts, which remain constant throughout, with the exception perhaps that they appear to be a little higher in the northern portion of the ranges.

The incidence of heavy fog on the crests of the mountains was discussed in the introductory part. It remains to point out that the lower level of the fog is observed to coincide very closely with the timber line. This indicates that the intensity of illumination is reduced by the fog for more than half the time to much below the requirements of tree species, particularly *Nothofagus Menziesii*, which could enable them to compete successfully against scrub. Measurements with a photoelectric cell show that the direct mid-day sunshine is reduced by about 200 times immediately underneath cloud ceiling, while in the fog it may be reduced by 1,000 times

and more. Examination of the uppermost branches of *N. Menziesii* taken from various altitudes of lowered timber line in sheltered places shows annual radial increment of about .2 mm. for the first three or four years. In similar specimens taken from the timber line at maximum altitude (1200 m.), where sunshine is much more abundant, the increment is about .1 mm. At the same time the trees at this altitude show every indication of having reached the coldest level at which they can compete satisfactorily. They are of low stature, hardly 3 m. high or much lower, with flat crowns and long spreading boughs. Examples of these are commonly to be seen in the central and eastern ranges, where they are bordered by the meadows of the higher belt. The timber line is quite different where it is more or less appreciably lowered. The line is very broken, odd patches of trees jutting out frequently well above the general level and occasionally quite separating from the main body of the forest. The trees themselves are, as a rule, perfectly formed, standing with their crowns two to three times above the scrub species, which are here some 3 or 4 m. tall.

The regeneration of forest at timber line at its maximum altitude is a continuous process. There is plenty of light reaching the floor. When the old trees die, seedlings quickly take their place. The timber line there is thus fairly fixed. On the other hand, the lowered timber line is always slowly advancing upwards until it is cut off from the rear and the process begins anew. Under the scrub, within a few metres of the forest, tree seedlings appear in great numbers, some of which survive the competition for light. Seedlings are also numerous for a few metres within the forest, but farther back they seldom survive the dense shade. The scrub species, particularly *Olearia Colensoi*, are much more shade-tolerant and can exist where tree seedlings perish. The result of this is that when the old trees begin to die their place is quickly occupied by scrub and the new timber line is formed below. Occasionally a patch of scrub may be adversely affected in some way, as, for example, by severe attack of a certain moth caterpillar on *O. Colensoi*; *N. Menziesii* is then able to establish quickly in a cleared space. The lowered timber line is thus continually fluctuating under the severe competition for light.

Relation to Rainfall.

Detailed information on the distribution of rainfall is not available, but the variation in the amount of it can be deduced, satisfactorily for the present purpose, from the study of the effects produced by it. The density of the vegetation in general, the abundance of epiphytes and bryophytes, all serve as useful indicators, while the presence or absence of a number of characteristic species indicates unmistakably the relative amount of precipitation. The Tararuas are not high enough to cause the rainfall to vary much from one place to another. In general the western slopes everywhere receive a somewhat higher precipitation than the eastern. The difference is greatest where the two sides are separated by greater distance and higher intervening ranges. Thus, in the central Tararuas, the general aspect of the warm temperate belt on the

eastern side has little resemblance to that of the same belt on the western. However, the difference practically disappears within the lower half of the lower cold temperate belt. Higher still the conditions are not strictly comparable owing to the difference in illumination. The rainfall here, in all probability, exceeds 250 cm. per annum (Kidson, 1930). February is probably the driest month, when even the wettest ground of the warm subpolar may be parched for a few days at a time.

The distribution of the species of *Nothofagus* is of special interest. First of all the absence of *N. cliffortioides* is noteworthy. This species inhabits fairly dry localities in the cold temperate belt, but as such are absent from the Tararuas, so is the species. Its place for the greater part is occupied by *N. Menziesii*, which normally inhabits the wet cold temperate belt. North of Mount Dundas, however, where a peculiar combination of low rainfall and heavy fog prevail, both species are absent, and their place to some extent is taken by *Dacrydium bifforme*. *N. fusca* tolerates a fairly wide range of precipitation and is widely distributed. It ranges mainly throughout the lower cold and upper warm temperate belt, but is practically absent from the latter on the western side, being ousted by *Dacrydium cupressinum* and *Metrosideros robusta* forest. Both *N. truncata* and *N. Solandri*, especially the latter, occupy much the driest portions of the mountains. They extend through the warm temperate belt south of Mount Alpha.

There are four distinguishable rainfall areas on the Tararuas, characterised by their own floristic elements.

The *Southern Tararua Area*, consisting of the Hutt River Basin and the Rimutaka Ranges, is the driest of the four areas. It is effectively screened by the range (now for the most part devoid of primitive vegetation) rising to some 600 m. and running along the coast from Wellington to Mount Kapakapanui. The northern boundary extends approximately from Mount Wainui over Mount Omega to Mount Reeves. The area is characterised by the presence of the following species: *Nothofagus truncata*, *N. Solandri*, *Danthonia antarctica*, *Cheesemania*, *Raoulia glabra*, *Leucopogon fasciculatus*, *Cyathodes acerosa*, *Leptospermum scoparium*, *L. ericoides*, *Heli-chrysum glomeratum*.

The *Northern Tararua Area* has its southern boundary ill-defined. The latter runs approximately over Mount Waiopahu, Mount Dundas, and Mount Bruce. The mountains north of this line lie in the rain-shadow of Mount Egmont and considerably inland. Being for the most part low, they intercept comparatively little rain. The characteristic species are: *Dacrydium bifforme*, *Phyllocladus alpinus*, *Veronica catarractae*, *Elatostema rugosa*.

The *Western and Eastern Tararua Areas* occupy the central portion of the mountains. The difference in rainfall between the two areas is already indicated. In addition, in the Eastern Area, the sunshine is much more abundant at higher altitudes than in the Western, and hence there is a greater luxuriance of vegetation and more prolific flowering. It is convenient therefore to draw the boundary between the two areas approximately in a straight line over Mount Arête and Mount Omega.

The Western Tararua Area is characterised mainly by the abundance of epiphytes and luxuriance of undergrowth particularly in the warm temperate. The entanglements of *Rhipogonum scandens* and *Freycinetia Banksii* form an outstanding feature. *Beilschmiedia tawa*, *Gleichenia Cunninghamii* are abundant, while the almost complete absence of *Veronica catarractae* and *Elatostema rugosa* as well as *Nothofagus truncata*, *N. Solandri*, *Cyathodes acerosa*, and *Leucopogon fasciculatus* is noteworthy.

In the Eastern Tararua Area the last four species are more or less characteristic. The epiphytes are not nearly so profuse as in the Western Area, the undergrowth is much thinner, and the ground is littered with dead leaves. The forest floor generally is remarkably free of fallen logs. Apparently the decay proceeds here very rapidly as compared with the Western Area. There the ground is strewn with dead logs often as large as 2 m. in diameter. They are thickly covered with bryophytes, filmy ferns, and other plants which quickly form a thick layer of permanently wet humus, the latter acting as a blanket, preventing free circulation of air and slowing down the processes of decay. In the upper cold temperate belt of the Eastern Area the abundance of pendulous *Osnea* sp., which is practically absent elsewhere, is a striking feature.

Relation to Humidity.

Humidity in general is more or less directly connected with precipitation and fog formation. These aspects of it have already been discussed sufficiently for the present. Humidity due to evaporation is of some slight interest. Vegetation is always much more luxuriant along river banks and other masses of water particularly in this Eastern Area. Even in the cold temperate belt, where precipitation is high, along the smallest water-courses the bryophyte flora is especially rich. The pendulous mosses and liverworts such as *Weymouthia* and *Lapicolea* abound.

Of greater interest, however, is the lowering of humidity brought about by wind. This agent, by removing the comparatively saturated atmosphere from the immediate neighbourhood of plants, causes steepening of the saturation gradient in the vicinity of the transpiring surfaces, thus greatly increasing the rate of transpiration. The result of this is an appreciable reduction in leaf-surface, and, as a consequence, decreased rate of assimilation, and, hence, growth. In the most adverse conditions such as exist on Mount Omega, 1100 m., which is subject to severe dry north-westerly winds descending from the main divide, the leaves of *Nothofagus Menziesii* are reduced to half the area of those growing in similar but sheltered places, such as certain places on the timber line, 1200 m., on Mount Alpha. The average length of leaves in the two places is about 7 mm. and 10 mm. respectively. The average rate of radial increment per annum of the uppermost branches is about .5 mm. and 1 mm. in the two respective places. Leaves of *Olearia Colensoi*, *Nothopanax Colensoi*, and *Pimelea longifolia* taken from the scrub formation from windward and leeward sides of several ridges, where the mechanical force of the wind is not evident, showed even greater variation. Although the respective places were only a few metres apart and separated

by the crest of the ridge only 2 or 3 metres above them, the average sizes of leaves of all species on the leeward side was found to be about four times greater in area than of those on the windward. The number of stomata in all cases was found to be the same in leaves from either side, but the venation was much denser in the leaves from the windward side. The annual rings were found to be twice as thick and internodes twice as long in the upper branches from the leeward side as in those from the opposite side.

The plants thus weakened are often unable to compete successfully against the invasion of communities otherwise to be found at higher levels. This type of modification of the vegetation is to be observed along many prominent ridges. Thus on the ridge leading to Mount Dinnan scrub is invaded by *Astelia Cockaynei*, which is generally associated with *Phormium Colensoi*. This in turn is invaded by *Danthonia antarctica flavesces*. The latter jordanon grows luxuriantly up to the highest peaks, 1500 m., but on exposed slopes it is generally replaced at about 1300 m. by a still more xerophytic *D. a. var.* (undescribed).

Relation to Wind Force.

The mechanical force of wind becomes appreciable on the higher ridges and particularly about flat tops and in saddles. The north-westerly wind often attains here a velocity against which it is almost impossible to proceed even by crawling. The surface in such places is generally bare of all but ground-hugging plants such as cushions of *Phyllachne Colensoi*, *Raoulia rubra*, and rosettes of *Anisotome aromatica* and *Oreomyrrhis andicola*. If the wind is more restricted in its direction, numerous narrow channels are worn in the ground with intervening strips of *Danthonia antarctica* and, perhaps, some other herbs and shrubs.

An interesting effect can be seen on Mount Omega, 1100 m. It is about the only place on the Tararuas where *Nothofagus Menziesii* is subjected to the direct force of extremely severe north-westerly gales descending from the main divide past Mount Hector. The wind is particularly concentrated at the broad top, which is swept practically clear of all vegetation, but behind every protruding rock *N. Menziesii* together with *Dracophyllum Urvilleanum* is to be found. The trees with tortuous and quite prostrate trunks stand not more than 50–100 cm. high and have perfectly streamlined "crowns." The greatest thickness of trunks observed was 15 cm. in diameter, but this varies greatly because of irregular growth. Branches 5 cm. in diameter were cut from three different trees. Their age proved to be about 300 years each. Accurate counting of annual rings was impossible owing to their extremely small size, often less than 2 cells thick, and a high probability that many rings were entirely missing. It is noteworthy that *Olearia Colensoi* is plentiful on the leeward side, but is practically absent for some distance down on the windward side, its place being taken by *Dracophyllum Urvilleanum*. The latter is always more plentiful than the former in the drier places, so that it is probable the phenomenon, as far as these two species are concerned, is really brought about by the drying effect of the wind. However, the foliage of *Dracophyllum* is undoubtedly more suited to resist the force of the wind than that of *Olearia*.

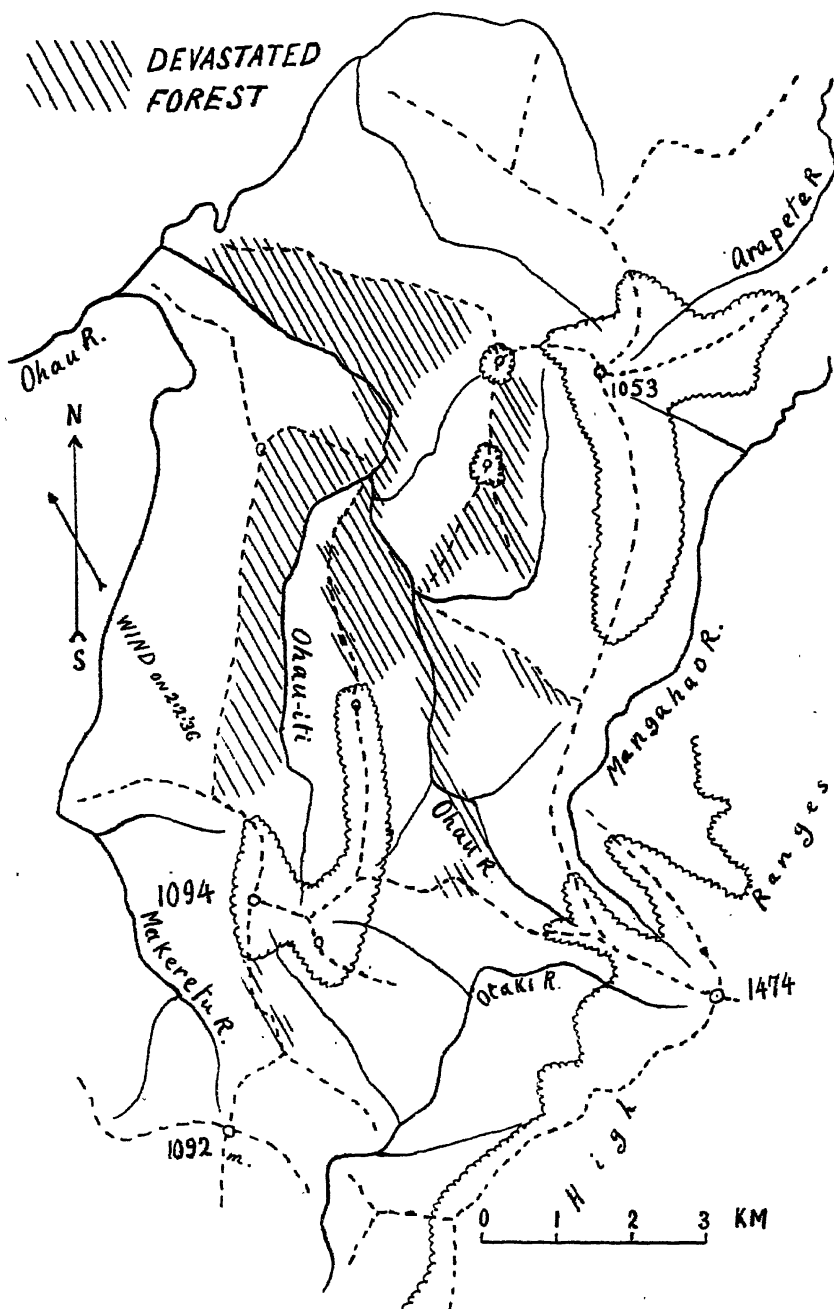
Practically everywhere at this maximum altitude for the timber line the forest roof has a peculiar levelled surface. This appears to be due to low temperatures and high insolation during clear weather causing transverse geotropism, rather than any direct or indirect action of wind. At least there does not seem to be any evidence to support the latter assumption.

There are three places observed in the cold temperate belt where forest is subjected to particularly severe descending north-westerly wind. These are the eastern slopes of Mount Baldy, just south of Mount Mitre, Mount Holdsworth, and Mount Matthews. The trees there never reach maturity, their diameters seldom exceeding 20 cm. The floor is strewn with decaying and still living overturned trees. During a high wind the trees rock violently, lifting boulders of considerable size upon their roots and dropping them down again with a deafening clatter. Uprooted trees up to 2 m. in diameter are not uncommon on the Tararuas everywhere, but these are, as a rule, either over-sized or over-aged trees.

As has been pointed out, the average velocity of the south-easterly wind is very low compared with that of the north-westerly, yet, on rare occasions, perhaps less often than once in a lifetime, it may attain great velocity. "During the night of the 1st and the morning of the 2nd (February, 1936) a deep cyclone, which had originated some days before as a tropical cyclone to the north-west of the New Hebrides, rapidly increased its spread of movement, travelled down the western side of the Auckland Peninsula, and thence across the centre of the North Island and away in a south-easterly direction." (Dominion Meteorological Office, 1936.) On the Tararuas the south-easterly wind began to be felt about 8 a.m. on February 2 and it gained its maximum force between 10 a.m. and mid-day. In those two hours whole hillsides of forest were completely levelled. The main destruction occurred in the foothills in the Western Area and the south-western portion of the Northern Area. The wind swept downwards from over the main ranges, concentrating its force upon the eastern slopes and along the valleys. Small trees and forest giants suffered alike. Some of the wrenched-out roots stood on edge some 8 m. high and up to 20 m. in spread, leaving hollows in the ground up to 2 m. deep. Of mature trees *Dacrydium cupressinum* appears to be the only one which was capable of withstanding the blast. Although badly battered, there are many trees of this species to be seen standing alone amidst destruction. They owe their preservation partly, no doubt, to their superior root development, but, probably, largely to the pendulous nature of their branches, which offered relatively small resistance to the wind. Numerous trunks of *Metrosideros robusta* also stand, but they are mostly stripped of their crowns. A portion of the affected area is shown on the accompanying sketch-map.

Relation to Snow-fall.

Snow-fall, like wind, possesses appreciable mechanical force. A striking instance occurred in the Eastern Area. Heavy snow fell during the 3rd to 6th August, 1932. It was especially calm on the last day of the fall. Consequently a large volume of snow was



Sketch map to show some of the area affected by the storm of
2/2/36.

caught by the branches, and its enormous weight snapped great boughs and occasionally completely stripped large trees of their crowns, forest in the warm temperate belt suffering particularly severely. This effect of snow, although on a smaller scale, is quite common in the cold temperate belt in fairly sheltered localities. Thus, about Mount Alpha Hut trees stand well spaced, often with almost bare trunks except for the small surmounting crowns. The stripping of branches, which does not affect all trees in the same year, accounts for the very erratic thickening of annual rings.

In the subpolar belt as much as 100 to 150 cm. of snow may fall at one time, and a somewhat greater thickness accumulates during winter months. The weight of snow, especially on the steeper slopes, has the effect of rolling down the vegetation. Further, where it accumulates, it lasts into the late spring, considerably shortening the growing season. Under it, formations similar to those of boggy ground occur. Particularly characteristic species are: *Astelia linearis*, *Coprosma repens*, *Caltha novae-zeelandiae*.

Relation to Frost.

Occurrence of frost has a different ecological effect from that of variation of temperature in general. Its effect is particularly noticeable on the flowering shoots of many subpolar belt species, which are not infrequently killed. *Anisotome dissecta* and *Chrysobactron Hookeri* suffer heavily in this way. The effect on the distribution of *Ranunculus insignis* is of interest. The latter is never found on eastern or northern aspects except in deep ravines. It appears that the rapid thawing after a frost is injurious to this plant. Most plants, however, appear to be quite hardy to the frosts affecting their habitats.

Relation to Slope and Soil.

The aspect of the slope in the forest, at any rate, does not appear to be of much consequence, provided climatic factors have been considered separately. A much greater effect on vegetation is brought about by the degree of slope, as this is closely associated with soil development and moisture content. As the slope becomes steep trees become unable to obtain sufficiently strong root-hold. Shrubs persist in crevices even on almost vertical slopes provided the moisture supply is adequate. The steep slopes in the subpolar belt are generally well supplied with percolating moisture. Their soil is usually thin, but densely covered by the so-called "rock garden." The following usually abound in such places: *Anisotome dissecta*, *Leucogenes leontopodium*, *Celmisia spectabilis*, *Ranunculus insignis*. On the less inclined slopes the soil is much thicker and is covered by meadows of *Danthonia antarctica*, which is usually associated with *Astelia Cockaynei* in somewhat steeper places. In many places steep slopes run into scree which attain extensive proportions on the eastern side of Mount Matthews ridge. Plants establish themselves with difficulty in such places and often their associations do not reach the climax before the next soil movement begins. On some slopes of Mount Matthews it never seems to end, even under forest.

On more or less flat surfaces and around springs the soil is often almost permanently wet and is hummocky and spongy. The vegetation here is usually very dense but not more than 10 cm. tall. This peculiarity is apparently due to deficiency of soil air. At any rate, the soil is quite warm, indeed, much warmer in the direct sunshine than under the adjoining tussocks, and it does not appear to be stagnant, water in the pools being as fit for drinking as in the streams issuing from them. All plants inhabiting such places send roots out more than 10 cm. down, and a large portion of the species is composed of liverworts and mosses.

There are few places which can be termed bogs. The outstanding examples of these are known near the top of Mount Omega and near the top of Mount Oriwa (900 m.), the Oriwa Lake-Hollow, about 3 km. south of Mount Waiopahu. On Mount Omega (1100 m.) this was once a *Dracophyllum Urvilleanum* association in a *Sphagnum* bog of about one hectare or so in extent. It is now very much altered by the continual trampling of deer. Oriwa Lake-Hollow is in reality but a slightly depressed elongated area of a few hectares in extent, surrounded by *Nothofagus Menziesii* forest. It appears to have once been a continuous *Sphagnum* bog with but few spermatophytes in its association. Now, however, about half of it is drained (there is an outlet) and is occupied by scanty growth of *Agrostis Dyeri*, *Uncinia compacta*, *Epilobium pedunculare*, *Gnaphalium Mackayi* and a few others together with *Celmisia gracilentia*. The latter species is known to occur in abundance only in this place and a somewhat similar one on Mount Kaiparoro, otherwise it is a rare species occurring along the eastern side. Of shrubby species only *Pittosporum rigidum* and *Coprosma parviflora* occur in the drained area as stunted shrubs.

Relation to Local Climatic Variations.

There are on the Tararuas a number of small areas where unusual combinations of climatic factors occur. These result in peculiar local modifications of vegetation, often very unlike that of the larger areas in which they are situated.

The Manawatu Gorge, and also to some extent other larger gorges in the Northern area, owing to the presence of a large body of water, is comparatively humid and its mean temperature near water is appreciably lower than in the surrounding country. Further, although the absolute amount of illumination is much smaller in the gorge, the relative amount available to shrubs and smaller plants is much larger than it would be under forest conditions. Here, therefore, a number of heliophytes are found on the steep rocky faces, e.g., *Myoporum laetum*, *Dodonaea viscosa*, *Edwardsia tetraptera*, *Carmichaelia odorata*, *C. filiformis* (?), *Phormium Colensoi*. The usually epiphytic plants, *Astelia Solandri*, *Cyclophorus serpens*, *Earina autumnalis*, festoon higher rocks. A specially interesting association occurs on rocks in the Manawatu Gorge just above the flood level. This consists mainly of *Danthonia setacea setifolia* (probably), which extends generally through the gorges of Northern Area, *Festuca multinodis* var., both of the latter apparently locally endemic. *Cladium Sinclairii* also occurs there but nowhere else on the Tararuas. The occurrence of *Rubus squarrosus* on the drier rocks

is of interest, while in the forest extending but little further south are to be found *Adiantum formosum*, *Arthropteris tenella* and *Oplismenus undulatifolius*.

Cape Turakirae and the mouth of Muku-muku River have a somewhat similar climate to that of Manawatu Gorge, but being completely isolated from the latter they have their peculiar floristic element. On the cliffs here, too, *Phormium Colensoi* is prominent. *Festuca multinodis* var. is abundant. *Danthonia setacea* is absent, but its place at Muku-muku River is taken by *D. bromoides*. *Senecio Greyi* is also abundant here, as well as *Muehlenbeckia axillaris* and some *M. Astoni*. *Trisetum Youngii saxeticolum* seems to be endemic to the coastal slips of this locality. *Coprosma retusa*, *Myoporum laetum* are prominent on the cliffs, while *Corynocarpus laevigatus* is generally abundant on the old fans.

Paekakariki hill cliffs are characterised by the presence in quantity of *Coprosma retusa*, *Muehlenbeckia axillaris*, *Myoporum laetum* with the addition of some characteristic subtropic element, which extends up the hillsides for some 300 m. It must be noted that the cold south-easterly wind descending strongly from over the range becomes appreciably warm here, and this raises considerably the mean temperature. The characteristic species which are not to be found elsewhere on the Tararua are the following:—*Disozylum spectabile*, *Melicope ternata*, *Mida Cunninghamii* and *Carmichaelia australis*.

Mangatainoka and Upper Ruamahanga River basins have wide valley floors and fairly gentle valley slopes. The rainfall here is very low, especially in the Ruamahanga basin. Consequently the forest is very light and a fair amount of light reaches the floor. Whether there are other modifying factors involved is not certain. However, a number of species which as a rule keep above 600 m. descend here to almost 400 m. Especially noteworthy are *Blechnum capense minor*, *Libertia pulchella* and *Pseudowintera colorata*. In the Ruamahanga basin on the northern slopes between 400 and 500 m. the undergrowth under *Nothofagus fusca* is most peculiar in the assemblage of species. Here *Hebe salicifolia*, *Leptospermum ericoides*, *Olearia arborescens*, *O. Colensoi*, *Senecio elaeagnifolius*, *Coprosma foetidissima*, *C. rotundifolia*, *C. Colensoi*, *C. Banksii*, *C. rhamnoides*, *C. robusta*, *Hoheria sexstylosa*, *Melicytus lanceolatus*, *Schefflera digitata*, *Nothopanax arboreum*, *Brachyglottis repanda*, *Coriaria arborea*, *Gaultheria antipoda*, *G. rupestris*, *Suttonia salicina*, *S. australis*, and *Astelia nervosa*, representing wet and dry areas, and warm and cold belts, all grow together. Of especial interest, however, is the occurrence here of *Coprosma tenuifolia*, which does not occur elsewhere on the Tararua.

Above the Ruamahanga River on the spur leading to Mount Pukeroa there is an extensive and almost pure association of *Olearia Colensoi* which extends vertically from mixed scrub at about 850 m. to 1200 m. The climate here is also noticeably dry and from various observations appears to be characterised by frequent dense but fine fog.

A little further north of this, on the long spur leading from Mangatainoka River to Mount Ruapai conditions appear to be even drier. Here at about the same altitudes *O. Colensoi* is completely absent and extensive areas are occupied by a dense association of *Danthonia setacea setifolia*, an association not to be seen anywhere else on the Tararuas.

The Park and Waiohine-iti are two parallel glaciated valleys in the central Tararuas. Their floors in the upper reaches are at about 900 m. altitude and are guarded on all sides by ridges well over 1200 m. with steep almost precipitous slopes. The wind in the valleys, judging by the vegetation, never assumes high velocity, and always blows up the valleys irrespective of the wind above it. It appears that the drying effect of the eddy currents must be appreciable. Further, the rainfall is probably considerably reduced by the high ridges. The steepness of the slopes and the porous nature of the soil of the valley floors must add to the general dryness of this local climate. At any rate, the total effect is to stop the forest abruptly on the valley sides, as well as on their floors, some distance below their heads. Scrub advances little further, tussock covering the remaining portions. That the conditions there must be rather dry is evidenced by the occurrence of fires, which, started accidentally by deer-stalkers, run through the tussock. Such fires occur only on the eastern side of the ranges, which is comparatively dry. In the Waiohine-iti Valley *Deschampsia tenella*, *Agrostis alpina*, *Brachycome Sinclairii* are common but are rare elsewhere. In the Park Valley *Hypolepis millefolium* is plentiful on valley slopes among tussock. On the valley floor *Danthonia setacea setifolia*, *Blechnum penna-marina* (the only record from Tararuas), *Ranunculus acaulis* are common. *Gnaphalium trinerve* is characteristic among the rocks along the river-bed. Of the grass species *Danthonia antarctica* (the variety of high ranges) is characteristic of both valley floors. It grows luxuriantly, reaching 100-150 cm. in height as compared with its usual stature of 20-30 cm. on the high wind-swept ridges.

In the Wairongomai River basin the lower warm temperate belt exhibits several odd features. The dominant tree here is *Podocarpus spicatus*, which is very rare or absent elsewhere. Amongst it, especially along the foot of the slopes, there are patches of *Laurelia novae-zealandiae*. *Knightia excelsa*, *Beilschmiedia tawa*, *Macropiper excelsa*, *Rhipogonum scandens*, *Leucopogon fasciculatus*, *Coprosma rhamnoides*, *C. rotundifolia* and patches of *Leptospermum ericoides* and *L. scoparium* on young river flats are also common. Except for *Podocarpus spicatus* the general aspect of the vegetation here very strongly resembles that of the Northern Areas.

The occurrence of small but almost pure stands of *Phyllocladus alpinus* at about 700 m. on a ridge leading to Mount Ngapuketarua and on Renata are noteworthy, especially the latter, which is an entirely isolated colony. Similar stands of small trees of *Dracophyllum Urvilleanum* occur at about 800 m. on the ridges leading to Mount Ruapai and some of those to Mount Matthews.

On Mount Macintosh exists a very peculiar association of *Schoenus pauciflorus* and *Olearia Colensoi*, the latter being not more

than 15 cm. high (200 cm. is its usual stature). The turf thus formed is very dense and spongy underfoot. At the time of visit (end of December, 1930) the ground was saturated with water although the slopes are quite steep and there was that day only a light fog. It may be observed that this place is especially subject to heavy fogs and thus there is probably severe deficiency in both sunshine and soil oxygen supply, resulting in extreme depauperation of *O. Colensoi*.

Interrelation of Plants.

So far only the general relation of plants to the climate has been discussed. Plants, however, modify greatly climatic conditions in their immediate neighbourhood, and this is especially pronounced within such formations as, e.g., tall forest.

Metrosideros robusta, the common rata, furnishes an outstanding example. It is a tall forest tree, but its massive trunk is not a true stem but a single or a number of more or less fused roots. It is a light-demanding large bushy "shrub" which cannot exist on the forest floor (at least not on the Tararuas). Instead it commences its life as an epiphyte high up in the forks of the tallest trees. It then sends to the ground one or more slender roots, which finally become established in the soil and function as ordinary stems. These stems often surround the foster tree at its base and in the early stages also clasp the trunk of the supporting tree more or less permanently by lateral roots. This fact, together with that of rata surviving long after the death of its foster tree, led Kirk (1872) to believe that the former strangles the latter. On the Tararuas the foster tree is usually rimu, *Dacrydium cupressinum*, and the dead trunks of these are commonly to be seen. The author, however, was never able to detect any evidence of strangulation. The explanation of the death of the rimu is to be sought in its failure to compete successfully for light. Rimu, like rata, is also a strong light-demanding plant, as is evidenced by its habit of growth. Once, however, its crown is overtopped by the epiphyte it is doomed to die.

Rata is found in abundance in the wet Western Area and is practically absent in the dry Eastern Area. This is in keeping with the profusion of epiphytes in the former and their paucity in the latter. In the forks of tall trees in the Eastern Area the conditions are generally far too dry for any large epiphytes, such as *Astelia Solandri* or *M. robusta*, to become established.

A few trees with true stems often behave, particularly in the Western Area, in a similar manner to rata. Among these *Nothopanax aboreum*, *Melicytus ramiflorus*, *Weinmannia racemosa* are conspicuous. They not infrequently begin their life 8 to 10 m. above ground but finally establish their roots in the ground. In this area large numbers of ferns, many shrubs, and a good few trees in their juvenile stage exist among true epiphytes well above ground. This is rendered possible through a dense growth of true epiphytes such as many filmy ferns, bryophytes and astelias. Further, many species are either driven out of existence in this area by the dense shade produced by more vigorous plants, or are driven up tall trees to assume an almost epiphytic habit. *Senecio Kirkii* is a noteworthy example of the latter group in the warm temperate belt. Under the entangle-

ments of *Rhipogonum scandens*, due, no doubt, to the dense shade produced by it, the ground is often practically bare of all other growth. Here *Freycinetia Banksii* is usually a lofty climber, but where plenty of light reaches the ground, as on some ridges and steep slopes, it frequently spreads over large areas of ground almost to the complete exclusion of all small plants and even shrubs.

Nothofagus Menziesii is usually a fairly deep-rooting tree, but in many places, especially in the upper cold temperate belt, its root system is to a large extent on the surface or even elevated up to some 50 cm. above ground. This is brought about by a dense unbroken mat usually of *Hymenophyllum multifidum* spreading over them and holding a permanent supply of moisture.

Interrelation of species is best observed in the succession and regeneration of the vegetation. Only brief notes can be made on these points at present. Regeneration of forests is more or less a continuous process depending on the amount of light falling on the forest floor. The soil is full of seed, and seedlings or what pass for such, 20 to 30 years old trees, begin to grow rapidly when opportunity arises. It is interesting to note that an examination of annual rings of *Nothofagus Menziesii* trunks of varying diameters up to 20 cm. at 1 m. from the ground proves them to be all of the same age in any one place.

In the warm temperate belt in the Southern Area in many places vegetation is unstable owing to continuous creeping down of screes which are very extensive, particularly in the Muku-muku basin. *Nothofagus* forest appears to be the climax association but this on the steeper slopes seldom develops. There are many places where screes have apparently resumed active movement comparatively recently. Their surfaces are strewn with dead logs.

When the movement slows down *Raoulia tenuicaulis*, *Danthonia semiannularis*, *Poa anceps*, *Acaena sanguisorbae*, *Paesia scaberula*, *Blechnum procerum*, *B. fluviatile*, *Epilobium* spp. and some other herbaceous plants arrive among the first colonisers. These are followed by *Leptospermum ericoides* generally in association with *Cassinia leptophylla*, *Cyathodes acerosa*, *Leucopogon fasciculatus*, *Helichrysum glomeratum*, *Hebe salicifolia*, *Rubus cissoides*, *Brachyglottis repanda*, *Cyathea Smithii*, and others. In the succeeding stage *Melicytus ramiflorus*, *Alectryon excelsum*, *Weinmannia racemosa*, *Beilschmiedia tawa*, *Hedycarya arborea*, *Metrosideros* spp., *Freycinetia Banksii*, and *Rhipogonum scandens* become established and often form a fairly stable association. Various transitional stages are quite commonly met with. Occasionally old trees of *Leptospermum ericoides* with trunks up to 35 cm. in diameter are encountered in mature associations subsequent to that of *Leptospermum*.

Somewhat similar successions take place in other parts of the warm temperate belt on the Tararuas, but *Pteridium aquilinum* often takes a prominent part in the initial colonisation and is usually succeeded with difficulty by other plants. The screes, however, in the Eastern Area are not very frequent, while in the Northern and Western they are almost unknown. The rock in these screes weathers almost directly into clay and the place of the screes is taken by

frequent landslips. Usually landslips are quickly occupied by *Blechnum procerum*, *Microlaena avenacea*, *Brachyglottis repanda*. These are rapidly followed by most common species of undergrowth.

In the cold temperate belt throughout, regeneration on the landslips is very similar to that in the warm temperate in the Western Area, but *Hebe salicifolia* is generally the first to establish quickly a dense association.

Regeneration after fire, which is not infrequent in the warm temperate belt, particularly on the eastern side, whether accidental or purposeful, even after sowing down of pasture grasses, provided man does not interfere further energetically with natural processes, quickly brings the land under forest back to its original state. Here *Pteridium aquilinum*, *Pteris incisa*, *Blechnum fluviatile*, *Acaena sanguisorbae*, *Erechtites prenanthoides*, *Brachyglottis repanda*, with perhaps some *Leptospermum scoparium* and *Cassinia leptophylla* rapidly become established. These are followed by *Blechnum discolor*, *Hebe salicifolia*, *Geniostoma ligustrifolium*, *Rubus cissoides*, *Schefflera digitata*, *Coprosma australis*, and *Weinmannia racemosa*. On the western side the whole is often dominated by *Cyathea Smithii* with some *C. dealbata*. Successions then follow in the usual manner. In the drier regions *Nothofagus* always forms the climax association. In the wetter, the climax association is dominated by *Metrosideros robusta*, which supplants more or less completely *Dacrydium cupressinum*. *Beilschmiedia tawa* often forms a distinct association, which, however, in most cases appears to be an intermediate stage in succession, preceding *D. cupressinum*.

In the cold temperate belt fires occur almost exclusively, and then only rarely, in the Eastern Area. A conspicuous feature of regeneration here is the almost immediate growth of *Nothofagus* and *Weinmannia*, or only the former, resulting in practically pure stands which for a long time afterwards are almost free from undergrowth.

In the warm subpolar belt fires are also restricted to the eastern side. The burns, as they are to be seen on Mount Mitre and in Park Valley, are quickly occupied by *Poa imbecilla* and *Agrostis Dyeri*. *Leucogenes leontopodium* and *Ranunculus geraniifolius* appear in quantity. Most of the perennial plants revive, as also do the tussocks of *Danthonia antarctica*, although more slowly.

Relation to Native Fauna.

So far as it affects the vegetation of the mountains the native fauna consists of Insecta, Arachnidia and Avis. Extremely little is known of the influence exerted by these on plants. Scale insects are numerous. Gall-forming insects and spiders occur on a number of small-leaved species of *Coprosma*, on *Shawia paniculata*, *Nothofagus fusca*, *Hoheria sexstylosa*, *Carmichaelia odorata*, and *C. flagelliformis*. Leaf-mining and chewing insects attack a number of species. Especially important among these is the larva of a moth which feeds on young leaves and buds of *Olearia Colensoi*. It seems to make its appearance in large numbers at a few years' interval, killing out vast areas of scrub. The old dead shrubs among later generations persist for many years before they decay and are to be seen in many places, having the appearance of having been burned. The last

appearance of the massed attack was first observed in 1933. Large areas of *Olearia* scrub are already destroyed and the insects are still (1936) spreading. Many scrub species are also subject to attack by various stem-boring insects. Besides their destructive activity many insects and particularly Lepidoptera and Diptera are of course important agents of pollination.

Birds exert their influence mainly in two directions: dissemination of species and destruction of insects. They are fairly plentiful in the forest, the following being common:—Tui (*Prothemadera novae-seelandiae*), bellbird (*Anthornis melanura*), kaka (*Nestor occidentalis*), pigeon (*Hemiphaga novae-seelandiae*), owl (*Ninox novae-seelandiae*), grey warbler (*Pseudogerygone igata*), fantail (*Rhipidura flabellifera*), rifleman (*Acanthisitta chloris*), tomtit (*Petroica toitoi*), N.Z. pipit (particularly on tussock) (*Anthus novae-seelandiae*). Fairly common: Whitehead (*Mohoua albicilla*), long-tailed cuckoo (*Urodynamis taitensis*), shining cuckoo (*Lamprococcyx lucidis*).

Relation to Man and His Agents of Destruction.

There is no evidence of activities of the Maori in the Tararua Mountains. Since the advent of the Pakeha, however, man's influence, direct and indirect, has wrought great changes in the vegetation.

As a first step to destruction of the primitive vegetation roads were made leading into most of the larger valleys. A highway made through the Manawatu Gorge connects the Manawatu River with Hawke's Bay and Wairarapa Plains. Another highway connects Wellington via Rimutaka Saddle to Wairarapa Plains. A little south of this the Wellington-Wairarapa railway crosses the range. The roadmaking has resulted in a most destructive effect on the primitive vegetation. In the author's own experience the native vegetation of the Manawatu Gorge has been reduced enormously within the last ten years. Partly through landslips, consequent upon cutting into hillsides to make room for the road, but largely through repeated cutting and burning of plants along the roadside, introduced plants have been able to obtain a strong root-hold. Among the latter *Foeniculum vulgare*, *Citysus scoparius*, *Senecio mikanioides*, and *Vinca major* are especially conspicuous, occupying large stretches.

Timber-milling was once in progress everywhere in the foothills, but now is confined mainly to the vicinity of Otaki Forks and Akatarawa River. *Dacrydium cupressinum* is the much sought-for timber tree. For the most part, especially in the earlier days, the rest of the forest was simply felled and burned and land converted into pastures. Good judgment was not always exercised. Numerous steep hillsides are now to be seen in the Eastern Area either covered with dense growth of *Pteridium aquilinum* or simply running into large screes.

Farms are not always fenced off from the forest reserves. Even so, as a compensation for the maintenance of the fences, farmers are allowed to run their stock a certain distance into the forest, and a few of them, especially on the eastern side, go as far as to run fires through the regenerating forest adjoining their properties. Because of this very fact that the cattle are allowed access to the

forest, the dense growths of shrubs and small trees along the margins are soon destroyed, free movement of air is permitted, humidity is appreciably decreased, and the larger trees die slowly but surely one after another through desiccation. Cases of this kind are fairly common.

There are two fairly large water-supply reserves: one, the upper Orongoronga River basin, controlled by the Wellington City Council, and the other, the Tiritea River basin, controlled by the Palmerston North City Council. There are also three large electric power supply dams: one across the Arapeti River and two across the Mangahao River. Practically all of the remainder of the forested area, as well as higher levels, is Crown land controlled by the State Forest Service.

Through the activity of many tramping clubs in the province practically every part of the mountains is accessible along well cut tracks, and their mountain huts provide shelter at frequent intervals.

Through the activity of early white settlers and especially of the Acclimatisation Societies a number of destructive animals of kinds not known in the country before have been introduced into it, some for purposes of sport, others for real or supposed commercial value. The history of introduction is to be found in G. M. Thomson's *Naturalisation of Animals and Plants in New Zealand*. Cambridge. 1922.

Deer (*Cervus elaphus*) has proved, so far, the most destructive animal on the Tararuas. It is abundant everywhere and especially on and in vicinity of the higher ranges. In many places the ground vegetation is reduced enormously by eating and trampling down. The spongy water-holding property of the soil is also greatly reduced by consolidation. The animal feeds apparently on many herbaceous plants. Of the woody, the following are much favoured: *Schefflera digitata*, *Nothopanax arboreum*, *N. Colensoi*, *N. Sinclairii*, *N. Edgerleyi*, *Griselinia littoralis*, *Coprosma australis*, *C. foetidissima*. Apart from feeding on the foliage of these species it also browses on their bark. It is quite common to see many of these trees completely ring-barked by deer from about 80 cm. to 160 cm. above ground. In a few places young *Podocarpus ferrugineus* suffers in the same manner. The bark of *Podocarpus Hallii* is often seen stripped, apparently by rubbing with antlers. All these, except perhaps *C. foetidissima*, usually die. At higher altitudes, when snow is on the ground, young *Cordyline indivisa* foliage is much favoured. Many meadow species of the subpolar belt are subject to severe grazing. In this respect the lot of *Aciphylla Colensoi* and *Danthonia antarctica* is conspicuous, especially where they grow more luxuriantly. The pungent, sword-like leaves of the former do not apparently offer it much protection, while the latter is often on many ridges trampled out of existence and the ground is laid barren. There are a number of places of several hectares in extent, such as are to be seen on top of Mount Quoin and the northern shoulder of Mount Omega, where the wet ground was once covered by luxuriant growth of *Danthonia antarctica flavescescens* nothing but the numerous decaying crowns of it still remained when last seen in 1933. Its place is now occupied by such low-growing bog species as *Carpha alpina* and *Orcobolus pectinatus*.

Wild cattle (*Bos taurus*) are rather restricted in their distribution on the Tararua and are practically confined to Otaki Valley, where they are plentiful. Their activity is similar to that of deer.

Goat (*Capra aegargus*) occurs in numbers in Western Area but is most abundant in the Southern Area. Its destructive habits are well known. Of the individual species attacked, *Carmichaelia* and *Edwardsia* seem to suffer most. Many of these plants are to be seen with their crowns hugging the ground, although many years old, because of continuous grazing.

Wild pig (*Sus scrofa*) is plentiful in the forest, but appears to be especially abundant in the warm temperate belt of the Northern Area. Thus, on the slopes of upper Ruamahanga basin, extensive patches of ground are to be seen thoroughly stirred up and practically devoid of ground vegetation, although sprouting seedlings are fairly numerous.

Opossum (*Trichosurus vulpeculus* and *T. fuliginosus*) is plentiful throughout the forest, and is being trapped under licence. Perham (1924) and Cockayne (1928) report very favourably on opossum and consider that it has no important influence on the forest. Recent observations, however, suggest that this animal, like deer, also has selective habits of feeding. Besides, it undoubtedly constitutes potential danger of getting out of control should the market price for its pelts depreciate.

Stoat and weasel (*Putorius* spp.) are reported by the opossum trappers to be numerous. Since they prey on bird life, they necessarily must have indirect effect on the ravages of insects. Nothing of an exact nature is, however, known in this respect.

Rats (*Mus decumanus*) and mice (*M. musculus*) are common, but rabbit (*Lepus cuniculatus*) and hare (*L. europaeus*) are absent. Sheep (*Ovis* sp.) never seem to penetrate into the forest or higher levels.

PLANT FORMATIONS.

V. D. ZOTOV, N. L. ELDER, and A. D. BEDDIE.

Plant population of the Tararua Mountains presents considerable diversity of character. In the present account only a general description of plant formation is possible. By a plant formation is understood a population dominated by certain species of a particular life form, which had reached its climax development under existing climatic and such edaphic environment which cannot be altered by plants themselves so long as the present geological processes continue undisturbed. Thus, the following important formations are recognised on the Tararua. In the warm temperate belt: tall forest, which includes *Metrosideros*, *Dacrydium*, *Beilschmiedia*, *Nothofagus*, *Podocarpus*, and other conspicuous associations; watercourse and riverbank; riverbed. In the cold temperate belt: tall forest (*Nothofagus*); watercourse and riverbank; bog; scrub. In the warm subpolar belt: tussock, herbfield, fell-field, screes, watercourses (including wet rocks), wet ground (including tarns and bogs).

Although these formations are essentially distinct and in general readily recognisable, yet in an area of this size there are bound to occur a number of formations which, though possessing distinctive characters, are of comparatively minor importance and these are somewhat arbitrarily classified together with some related group or else omitted from the present discussion to avoid delving into details. Thus, riverbank and watercourse in the warm temperate belt is extended to include cliff and coastal cliff formations. This has particular advantages in dealing with the southern extremity of the Rimutaka Range, where most of the coastal cliff of the area is situated, as the riverbank and coastal cliff associations are very similar. Tussock, herbfield and scree formations, though only listed for the warm subpolar belt, might have been, but for considerations of space, added as well for the cold temperate belt, in the upper part of which they are occasionally important, but these formations are essentially the same in the two belts.

Another problem which only affects the formations of the lowest zones, is that of dealing with the marginal areas where the indigenous communities have been to a greater or less degree altered or destroyed by the action of man. The boundary taken follows approximately the limit of unbroken forest from the Manawatu Gorge down either flank of the range and on the western side touching the coast at Paekakariki, below Mount Wainui, then cutting across the Hutt Valley to the head of the Wainui-o-mata River and following this to the sea. At the northern and western extremities the forest is, at the present day, discontinuous and some of the existing communities are more or less altered so that a certain amount of inference is necessary as to the original associations, the indigenous formation in which certain species occurred and, to a certain extent, the relative frequency of certain species.

Warm Temperate (0-600 m.) Forest.

Tall forest is the only important formation in this belt. In the lower portion of the belt, more especially in the Northern and Western Areas, the dominant canopy tree is *Metrosideros robusta* or *Dacrydium cupressinum*, the latter's trunk occasionally reaching 2 m. in diameter.

In the climax association *Metrosideros* rules, replacing its foster-tree. Often in the upper portion of the belt *Metrosideros* occupies the same position, but in many places *Nothofagus fusca* dominates. There are local communities where *Beilschmiedia tawa* dominates, particularly in the drier patches of the lower belt, while *Weinmannia racemosa* forms equivalent communities on the ridges of the upper belt. The latter is perhaps the most abundant tree numerically in the Northern and Western Areas. *Melicytus ramiflorus*, *Nothopanax arboreum*, *Hedycarya arborea*, *Knightia excelsa*, *Cyathea Smithii*, *Podocarpus ferrugineus* are also important constituents throughout the belt. In the lower belt *Rhopalostylis sapida*, *Cyathea medullaris*, *C. dealbata* are abundant, and *Carpodetus serratus* and *Olearia rani* common, while, where the ground approaches swamp, *Laurelia novae-zealandiae* is a physiognomic tree. In the upper part of the belt *Podocarpus Hallii* and *Suttonia salicina* occur in quantity.

Rhipogonum scandens, particularly in the lower three-quarters of the belt, often forms practically impenetrable tangles, and the shade underneath them is so complete that the floor is almost devoid of shrubby or herbaceous plants, and even bryophytes are scanty. *Freycinetia Banksii* also abounds, climbing by roots and heavily festooning trees with its long tufted foliage. Where sufficient light reaches the floor, especially on steep faces, it spreads in a dense entanglement, the heads rising 1-2 m. from the ground. Of other high climbers, *Metrosideros scandens*, *Clematis indivisa*, and to some extent *Rubus cissoides* also occur. In a lower tier, together with numerous young trees of the higher tiers, *Myrtus pedunculata* in dry stations and *Schefflera digitata* in wet are usually found, while with increase in altitude *Pseudowintera axillaris* and *Senecio Kirkii*, the latter at lower altitudes more usually epiphytic, come in. On the forest floor itself, forming a tier 1 m. in height, the following are abundant, one species now and again becoming dominant:—*Microlaena avenacea*, *Gleichenia Cunninghamii*, *Blechnum discolor*, *Polystichum Richardi*, *Asplenium lucidum* and *Uncinia riparia*. *Astelia Cunninghamii*, *Asplenium bulbiferum* and *Alseuosmia macrophylla* also occur frequently in places.

The ground, decaying logs, trunks and branches of trees and even shrubs are more or less clad with filmy ferns, mosses and liverworts. Large areas of more or less pure *Cardiomanes reniforme* are common, and the following are also plentifully distributed:—*Hymenophyllum dilatatum*, *H. sanguinolentum*, *H. bifforme*, *H. demissum*, while *H. tunbridgense*, *Polypodium Billardieri*, *Trichomanes venosum* are frequently present. Where more light can penetrate *Lindsaya cuneata* and *Histiopteris incisa* are common.

Perched on the canopy trees the following epiphytes are common: *Astelia Solandri*, *Dendrobium Cunninghamii*, *Earina autumnalis*, *E. mucronata*, *Asplenium flaccidum* and *Tmesipteris tannensis*.

The following species are common on the outskirts of the forest where the primitive covering has been broken in the course of settlement: *Pteridium aquilinum esculentum*, sometimes dominating limited areas, the climbers, *Muehlenbeckia complexa* and *Metrosideros perforata* and in clearings *Lagenophora pumila* and *L. petiolata*.

The warm temperate forest of the Northern Tararua Area is chiefly noteworthy for the absence, from about Mount Mairakau northward, of *Nothofagus fusca*, which is elsewhere plentiful, and for the presence in abundance of *Mida salicifolia* and *Macropiper excelsum*, while in the vicinity of the Manawatu Gorge *Myoporum laetum* and *Melicope simplex* are common. In the Mangahao valley, *Nothofagus Menziesii*, which further south is mainly confined to the cold temperate belt, descends into the warm belt in appreciable quantity. The Mangatainoka and Ruamahanga valleys also present some peculiarities of vertical distribution, which are dealt with in the ecological section of this paper under local climatic variations.

In the Eastern Tararua Area *Nothofagus fusca* dominates the climax association. *Weinmannia racemosa* is abundant in a lower tier, and the undergrowth, which is very open, is mainly composed of *Cyathocha Smithii*, *Coprosma Banksii*, *Cyathodes acerosa*, *Leuco-*

pogon fasciculatus, and *Coprosma rhamnoides* with some *Rhipogonum scandens* and *Freycinetia Banksii*. The floor is thickly covered with dry leaves of *Nothofagus* and *Weinmannia*. The most conspicuous filmy fern is *Cardiomanes reniforme*, which often covers large patches of ground. In some places, particularly where the ground is level, *Blechnum discolor* is plentiful. The bryophyte representation is poor.

In the Southern Tararua Area most of the lowland forest has disappeared. What is left, being fairly close to the sea, shows in several places traces of an admixture of coastal species. In the Muka-muka basin and on the western flank of the area *Corynocarpus laevigata*, *Myoporum laetum* and *Melicope ternata* are common, while on the west side in addition *Dysoxylum spectabilis* is plentiful. Apart from these areas, the dominant tree of the climax association appears to be *Nothofagus truncata*, co-dominant perhaps in some places with *N. Solandri*, the general aspect of the association resembling that of the Eastern Area, but the following additional species are common: *Danthonia flavescent* *Cheesemanii*, *Pittosporum tenuifolium*, *Macropiper excelsum* and *Melicope simplex*. *Knightia excelsa* and *Podocarpus spicatus* are also prominent, the latter dominating a local area in the Wairongomai valley.

Warm Temperate Belt: Watercourse, Riverbank, and Cliff.

The watercourse and riverbank formation is essentially younger in succession than the forest which it traverses and differs from it in two ways. Light is freely admitted to much lower levels, so that shrubby and herbaceous species predominate. The perpetual high humidity gives the formation its abundance of bryophytes and pteridophytes. Throughout the whole of the Tararuas there are but slight differences in the associations since they are but little dependent directly on rainfall. The ground generally is densely covered by ferns and mosses and the branches of trees are densely festooned with species of *Weymouthia*. Wet banks are usually occupied by *Gunnera strigosa*, with some *Gnaphalium keriense*, *Veronica catarractae* (little on the western side), *Pratia angulata* and occasionally *Ourisia macrophylla*. *Elatostema rugosum* is characteristic of the Northern Area. Frequently *Blechnum procerum* forms pure colonies of considerable area, attaining its maximum development on steep sheltered slopes. Of the taller shrubs *Fuchsia excorticata*, *Schefflera digitata*, *Aristotelia serrata*, young *Melicytus ramiflorus*, *Coprosma australis*, and, in better-lit situations, *Brachyglottis repanda* and *Hebe salicifolia*—the latter with several recognisable varieties occupying separate more or less defined areas—are most common. Of climbing plants *Rhipogonum scandens* and *Freycinetia Banksii* are often present and *Muehlenbeckia australis*, *Parsonsia heterophylla* and *Rubus cissoides* are not uncommon in the lowlands.

On the more exposed banks, and particularly in rocky gorges, *Carmichaelia odorata* is generally plentiful, and with increasing exposure *Phormium Colensoi* may make its appearance. Of ferns *Adiantum affine* and *Polypodium grammitidis* are common in rocky stations.

At the southern extreme of the area where the Rimutaka Range plunges steeply into the sea at Cape Turakirae the tributaries of the main streams are steeply graded shingle carriers and for several kilometres inland their vegetation is rather that of coastal cliffs than of lowland forest. On the rocky walls of the tributaries of the Muka-muka Stream the dominant species may be *Phormium Colensoi* or *Senecio Greyi*, with *Olearia paniculata*, *Hebe parviflora*, *Hebe salicifolia*, *Veronica diffusa*, *Linum monogynum*, *Craspedia uniflora* and *Poa anceps* and other small grasses commonly present. Towards the heads of these streams the association reverts to the general norm, with the exception of the local dominance as a creeping herb of *Jovellana repens*, elsewhere infrequent. In other valleys of the Rimutaka *Leptospermum scoparium* or *Coriaria arborea* and *Cassinia leptophylla* are prominent.

On the coastal cliffs *Muehlenbeckia complexa microphylla* and on the coastal screes *Raoulia australis* are common.

Warm Temperate Belt: Riverbed.

Riverbed formation is more distinctive than riverbank in that it is not in the direct succession to forest. As the shingle settles the first plants to colonise it are *Raoulia tenuicaulis* and *R. t. pusilla*, more commonly the latter. The plants spread quickly, forming a dense and often extensive overground mat, in the shelter of which *Pratia angulata* and *Acaena sanguisorbae* soon appear. Mosses are not of any importance. On the older established ground *Uncinia uncinata* v. —, *Juncus polyanthemos*, *Epilobium junceum*, *Gunnera strigosa* and perhaps also *Microlaena avenacea* become abundantly established. Except on the Western side *Lycopodium scariosum* is common. *Schizaelema trifoliatum*, *Cotula dioica* and, in the upper part of the belt, *Oxalis lactea* are occasionally plentiful. The climax association appears to be dominated by *Arundo fulvida*. When this is reached or even earlier the forest begins to encroach.

Riverbeds, being generally in close proximity to cultivated areas and not fully occupied by its plant formation, are open to the vigorous invasion of common pasture plants. Among these *Trifolium repens*, *Holcus lanatus*, *Anthoxanthum odoratum*, *Agrostis tenuis* and *Hypochaeris radicata* are the most aggressive, though most other species of the neighbouring district may occur here.

Cold Temperate Belt (600–1200 m.) Forest.

Practically everywhere but in the Northern Tararua Area the *Nothofagus Menziesii* association is the climax within the forest formation, and is practically the only tree to reach the upper limit of forest. With rise of altitude the trees usually become more stunted with close-cropped crowns and short gnarled branches, though on Hell's Gate (1200 m.) the species grows up to 10 m. tall—an exceptional height at this altitude—with trunks up to 1.75 m. in diameter at 1.5 m. above ground level. These are practically free from buttresses unlike those of *N. fusca*, which, when fully developed, frequently are supported by buttresses extensive enough to conceal several men at once.

Within the forest *Nothopanax Colensoi*, *Coprosma foetidissima*, growing characteristically in a series of curving wands from an

oblique main stem, *C. Colensoi*, *Suttonia divaricata*, *Olearia arborescens*, and, on the floor, *Polystichum vestitum* and *Gahnia pauciflora* are usually present in quantity. On tree trunks *Hymenophyllum sanguinolentum* and *H. multifidum* are often profuse, while on the ground, together with bryophytes, they form a dense green carpet almost perpetually saturated with moisture. The tree roots presently lift this from the ground leaving large cavities beneath, which add to the difficulties of progress.

Below 900 m. *N. fusca* is frequently the dominant species in the climax association, and it is in any case common, as are also *Podocarpus Hallii*, *P. ferrugineus*, and *Weinmannia racemosa*. Of these *Weinmannia* is practically the only species that continues into the upper belt and then in very much reduced numbers. The following smaller trees and shrubs, though plentiful in the lower part of the belt, are likewise seldom found above 900 m.:—*Suttonia salicina*, *Pseudowintera colorata* (frequently dominant in the Rimutaka Range), *Cyathea Smithii* and in somewhat fewer numbers *Griselinia littoralis* and *Nothopanax Sinclairii*. Beneath these, within 1 m. of the ground, *Blechnum discolor* or *Gleichenia Cunninghamii* may cover large areas of dryer ground, while in moist hollows, deeply shaded, *Leptopteris superba* often grows luxuriantly. *Myrtus pedunculata*, *Astelia Cunninghamii* and *Microlaena avenacea* are commonly present and on the ground or decaying logs, *Enargea parviflora* and *Libertia pulchella*, the latter being markedly consistent in its upper limit.

In the upper part of the belt and penetrating under favourable conditions even into the lower, the place of the shrubs of lower altitudes is increasingly taken by species more properly considered in the following section under the heading of scrub, such as *Olearia Colensoi*, *Senecio elaeagnifolius*, *Coprosma pseudocuneata* and *Pittosporum rigidum*, and *Astelia Cockaynei* which is more typically a plant of the tussock. *Danthonia Cunninghamii* is, however, a forest species and *Olearia lacunosa* mainly so, and these with *Phormium Colensoi* occur commonly.

In the Northern Tararua Area the cold temperate forest is, for the most part, not clearly defined. In the absence of *Nothofagus Menziesii*, *N. fusca* dominates the climax association on Tawhirikohukohu and in the vicinity of the Mangahao Dam, while *Phyllocladus alpinus* is occasionally dominant about Ngapuketuru. On the other hand *Nothofagus* is practically absent from the eastern side of the area and *Dacrydium biforme* is the dominant species. Otherwise, however, the associations found in this area are but slight modifications of those found elsewhere.

Cold Temperate Belt: Riverbank and Watercourse.

This formation is distinctive in a similar manner to that of the warm temperate belt, but in practically every case the riverbed formation dwindles, within the upper timber line, to insignificance owing to the steepness of the grades and becomes merged with the riverbank and watercourse formation. The latter is generally dominated by *Hebe salicifolia*, *Aristotelia fruticosa*, *Hoheria sexstylosa*

var., *Fuchsia excorticata*, *Pseudowintera colorata* and *Coprosma foetidissima*, while above 900 m. *Olearia Colensoi* and *Senecio elaeagnifolius* often take a large part. *Helichrysum bellidoides*, *Senecio Solandri* and *Ourisia Macrophylla* are common. *Uncinia* sp., *Microlaena avenacea*, *Danthonia Cunninghamii* and *Phormium Colensoi* may also occur in quantity. The bryophyte flora is rich.

Cold Temperate Belt: Scrub.

Scrub formation is extensive in the Northern Tararua Area and on the windward slopes of the Western Tararua Area, but only occurs elsewhere in very restricted extent. Where well-developed it is extremely difficult to penetrate owing to its denseness and the extreme rigidity of the terminal branchlets. Very often the only practicable method of progress is to worm one's way along the ground or even to walk upon the top of the shrubs, except where tracks cut open by tramping clubs or broken open by deer are available and at its worst even deer refuse to face it.

There are a number of distinct associations in the scrub formation, but the one dominated by *Olearia Colensoi* is by far the most common. Other species of significance are *Senecio elaeagnifolius*, *Coprosma pseudocuneata*, *C. foetidissima*, *Nothopanax Colensoi*, *Pittosporum rigidum* and *Dracophyllum Urvilleanum*, any one of which may become dominant in isolated places. Where scrub occurs in the lower portion of the belt *Weinmannia racemosa* is an important constituent and in the Northern Tararua Area *Phyllocladus alpinus*. *Olearia arborescens*, *O. lacunosa*, *Pimelea longifolia*, *Hebe buxifolia*, *Gaultheria rupestris* are very common and among these *Gahnia pauciflora*, *Danthonia flavescens* and *Phormium Colensoi* occur in many places. Under the scrub *Astelia Cockaynei* is generally plentiful and where light penetrates freely the following are found:—*Euphrasia cuneata* var. *tricolor*, *Gentiana bellidifolia*, *G. Grisebachii*, *Thelymitra uniflora*, *Danthonia nigricans*, *Agrostis Dyeri*, *Lycopodium fastigiatum*, *Gaultheria depressa*, *Nertera depressa*, *N. setulosa*, *N. dichondraefolia*, *Cyathodes empetrifolia*, *Blechnum procerum*, *Polystichum vestitum*, *Hymenophyllum sanguinolentum*, *H. multifidum*.

In several localities in the Northern Area, in particular at its boundary with the Western Area along the ridge between the Mangahao and Otaki rivers leading to Pukematawai, the entire upper part of the belt is under scrub which merges imperceptibly with the Subpolar Belt. Immediately above the timber line, which is here in the vicinity of 900 m., the scrub association is of the usual type, but with increase in altitude this becomes more and more intermingled with tussocks, at first of *Gahnia pauciflora* and later of *Danthonia flavescens*, which grow among the shrubs to a height of 2 m. or more. Higher up the slope shrub species decrease in stature and in numbers to give place to subpolar tussock.

A noteworthy case of scrub formation at a low elevation occurs on the eastern side of the range along the boundary of the Northern and Eastern Areas where it traverses the foothills east of Ruapai. Forest, with *Weinmannia racemosa* dominant and *Podocarpus Hallii*,

P. ferrugineus, *Dacrydium biforme*, and, unexpectedly, much-stunted *D. cupressinum* fairly common, merges, at about 800 m., gradually on northern and western aspects into tussock meadow with *Phormium Colensoi* strongly in evidence interspersed with scattered scrub species and some windswept *Leptospermum scoparium*, while on southern and particularly eastern faces a conspicuous fringe of stunted *Nothofagus fusca* marks the commencement of a dense scrub formation, dominated by *Olearia Colensoi*. Further along the ridge where, in the vicinity of Tawhero, it exceeds 900 m., the scrub is abruptly replaced by an almost pure association of *Nothofagus Menziesii*, absent elsewhere from the area.

Cold Temperate Belt: Bog.

There are a number of wet places of limited extent in the upper portion of the belt which, although not strictly bogs, may conveniently be classed as such. However, as the particular associations also occur in the Subpolar Belt, it will be convenient to treat of them there, the only additions to the species there listed being *Lyperanthus antarcticus*, *Prasophyllum Colensoi*, and a small-leaved form of *Ourisia* which are common. True sphagnum bog associations are nowhere extensive in the Tararuas and are confined to the cold temperate belt. The only two which are of any size are in Oriwa Lake-Hollow (Western Area) and on Omega (Southern Area) and these are described in the ecological section of the paper under soil and slope.

Warm Subpolar Belt (1200 m. +).

In the uppermost belt the scrub formation as such is absent, such shrubs as occur are usually scattered through the subpolar tussock, which is the most extensive formation. The following formations are also of some importance: herb-field, fell-field, scree and watercourse. Each, when fully developed, is very distinct, but very often they merge imperceptibly into one another.

Warm Subpolar Belt: Tussock.

The *Danthonia antarctica* var. *flavescens* association is occasionally found almost pure, but only in situations with a comparative degree of shelter from prevailing winds. With greater exposure its place is taken by *D. antarctica* var. —, a much narrower-leaved jordanon. On a sharp ridge the contrast in colour between the exposed and sheltered side is often most marked, the one pale and tawny, the other a luxuriant dark green. *Astelia Cockaynei* is also abundant and occasionally dominant, while *Dracophyllum rosmarinifolium*, a small heather-like species frequently occupying the crests of ridges, and *Olearia Colensoi*, growing as a semi-prostrate shrub about 50 cm. above ground on sheltered slopes, may be dominant over small areas. *Aciphylla Colensoi* var. *conspicua*, *Anisotome dissecta*, *Celmisia spectabilis*, *Pentachondra pumila*, *Chrysobactron Hookeri*, *Ranunculus geraniifolius* and the shrubs *Senecio Bidwillii* and *Hebe Astoni* are generally plentiful. *Dicranoloma* sp. are common ground mosses, but liverworts are practically absent, at any rate in most localities.

Warm Subpolar Belt: Herb-Field.

This is found mainly on the steeper slopes which are at the same time rather damp. The plants do not usually exceed 30 m. in height and are predominantly broad-leaved species. *Astelia Cockaynei* is occasionally dominant, but more frequently one of the following: *Anisotome dissecta*, *Celmisia spectabilis*, *C. hieracifolia*, *Senecio lagopus*, *Leucogenes leontopodium*, *Raoulia grandiflora*, or *Pentachondra pumila*. *Chrysobactron Hookeri*, *Dracophyllum rosmarinifolium*, *Senecio Bidwillii* and other herb-field plants are more or less common. Certain species of *Dicranoloma* and *Rhacomitrium* are generally plentiful on the ground.

On more exposed situations, such as rocks, especially on windward slopes, grey-green cushions of *Raoulia rubra*, together with the vivid green ones of *Phyllachne Colensoi* are conspicuous. Among the shorter herbs, *Plantago Brownii*, *Caltha novae-zealandiae*, *Drapetes Dieffenbachii*, *Epilobium pedunculare* and *Carex acicularis* are common, and of grasses *Deyeuxia setifolia* and *Poa Colensoi*, the latter even in abundance.

Warm Subpolar Belt: Watercourse.

As a formation, watercourse is barely distinguishable from herb-field, except in the variety of the species content and in the general luxuriance of vegetation due to the perpetual presence of water and comparative absence of wind, with corresponding increase of humidity. There are numerous associations to be met with, but the following species are characteristic: *Poa Colensoi*, *Epilobium glabellum*, *Montia fontana*, *Ranunculus insignis* and *Senecio lagopus*. In a few places, as, for example, on the south slope of Field Peak facing Mount Hector, *Cotula pyrethrifolia* is important, while in the watercourses to the east of Mount Arête, *Oxalis lactea*, *Senecio Solanderi*, *Epilobium glabellum* at 1300 m. are conspicuous.

The following are generally common: *Hierochloa Frazeri*, *Danthonia antarctica* (both var.), *Deyeuxia setifolia*, several species of *Epilobium*, *Schizaelema novae-zealandiae*, *Caltha novae-zealandiae* and numerous mosses and liverworts.

Warm Subpolar Belt: Fell-field.

Fell-field, if, in the Tararua Range, it may be so called, occurs on a few flat-topped, wind-swept knobs and shoulders, or on razor-backs, particularly in the neighbourhood of saddles. Two good examples are to be seen on either side of Mount Hector, the one on Field Peak, the other on the Dress Circle towards Mount Alpha. The associations here are formed mainly of cushion plants, small rosette plants, plants which grow closely appressed to the ground or which otherwise offer little resistance to wind. The following are the dominant species:—Cushions: *Raoulia rubra* (up to 2 m. in diameter, but more generally about 50 cm.), *Phyllachne Colensoi*, *Raoulia grandiflora*. Rosettes: *Anisotome aromatica*, *Oreomyrrhis andicola*, *Plantago Brownii*. Appressed: *Pentachondra pumila*, *Drapetes Dieffenbachii*, *Dracophyllum rosmarinifolium*, *Poa Colensoi*, *Lycopodium fastigiatum* and *Andreaea* spp.

Warm Subpolar Belt: Bog.

The chief characteristic of the area here considered is the close turf, forming a stiff crust to the soft peaty soil beneath and the sparse occurrence, depauperation or complete absence of the taller species of adjacent formations. A distinct xerophytic habit characterises all the dominant species, undoubtedly due to the fact that during the summer most of them dry up at intervals and perhaps also to their continual exposure to drying winds.

The dominant constituents of the association are usually some of the following: *Schoenus pauciflorus*, *Carpha alpina*, *Oreobolus pectinatus*, *Gaymardia ciliata*, *Astelia linearis*. Generally common are *Caltha novae-zealandiae*, *Plantago Brownii*, *P. uniflora* (especially on the brinks of tarns), *Isolepis Aucklandicus*, *Juncus antarcticus*, *Drosera stenopetala*, *Forstera Bidwillii*, *Caladenia bifolia*, *Coprosma repens*, and in several localities *Abrotanella pusilla*. Stunted forms of *Ranunculus geraniifolius* (particularly the variety with much dissected leaves), *Celmisia spectabilis*, *C. hieracifolia oblonga*, and *Senecio lagopus* are also commonly present.

DISTRIBUTION OF SPERMATOPHYTA AND PTERIDOPHYTA.

By V. D. ZOTOV, N. L. ELDER, A. D. BEDDIE.

Previously published lists of species collected from the Tararua Mountains are either too fragmentary or cover but isolated narrow routes only. Besides, the very scanty information supplied with them is often erroneous or tends to give an erroneous impression. It would appear from the information given in Cheeseman's *Manual* that about 236 species more than so far recorded from the Tararuas should occur there by reason of the fact that they occur on the mountains both north and south of the Tararuas. Because of the above reasons and the large amount of fresh information accumulated it is very desirable to publish a thoroughly revised and enlarged list of species together with notes on their distribution.

In the following list the past records are checked fairly, if not quite, completely, and persons making records are noted. Only the specific citations for the Tararua Mountains are here accepted as recorded for them.

In its arrangement of species the list closely follows that of the *Manual*, but a number of departures are made in nomenclature so as to bring this up to date as nearly as possible. No attempt is being made here to describe any new species and varieties or correct any known errors which crept into the *Manual* and which have not yet been formally published, except where this is absolutely necessary to avoid possible confusion. It is hoped that in all cases of alteration of specific names there is sufficient means of identifying them with those of the *Manual*. It must be stressed here that no attempt is being made to distinguish Tararuan jordanons from those elsewhere, although there is usually more than one very distinct jordanon in every species. Only in those species which are represented on the Tararuas by more than one recognised jordanon are the varieties indicated.

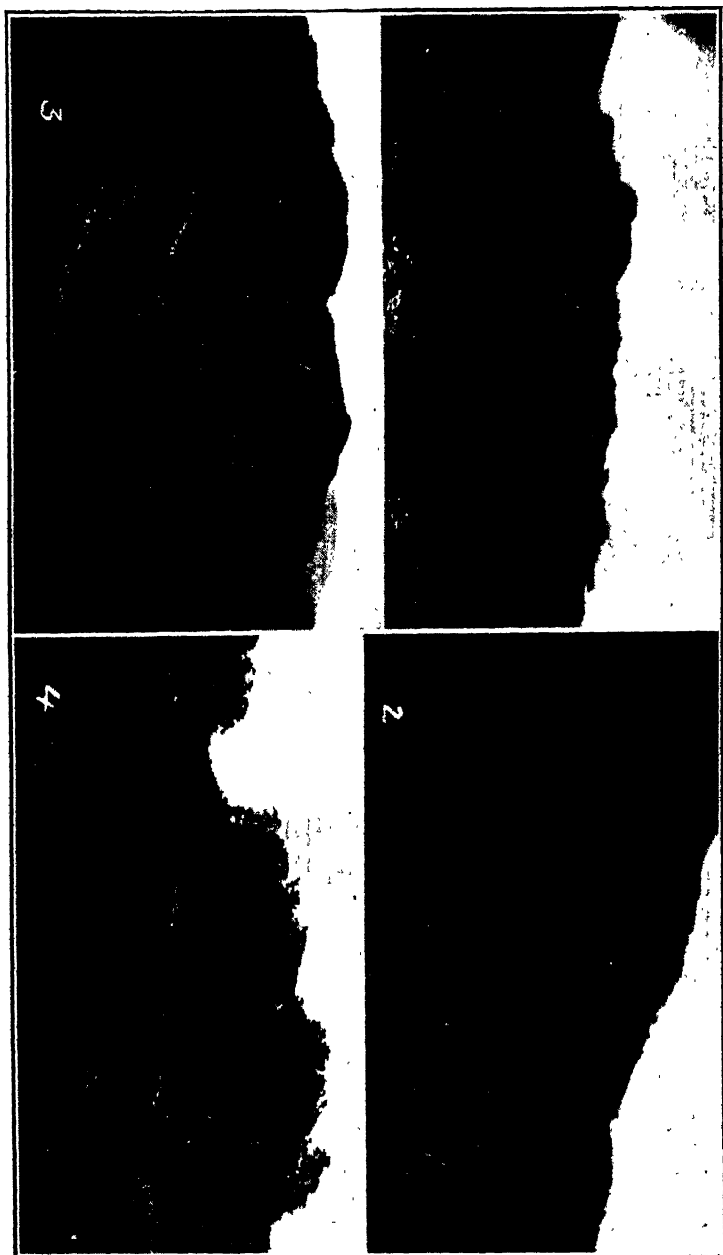


FIG. 1.—Timber-line at its maximum altitude. Eastern slope of Mt. Alpha, c. 1200 m. FIG. 2.—Forest advancing on to the scrub as being cut off from the main body of the forest by the scrub. South-western slope of West Peak (near Mt. Hector) c. 1050 m. FIG. 3.—Note effect of the moist north-westerly wind on distribution of formations. A small hanging valley just below the main divide (left) which is c. 1200 m., looking south. FIG. 4.—A naturally drained bog—now dry—but supporting only a scanty vegetation. Otira Lake-Hollow.

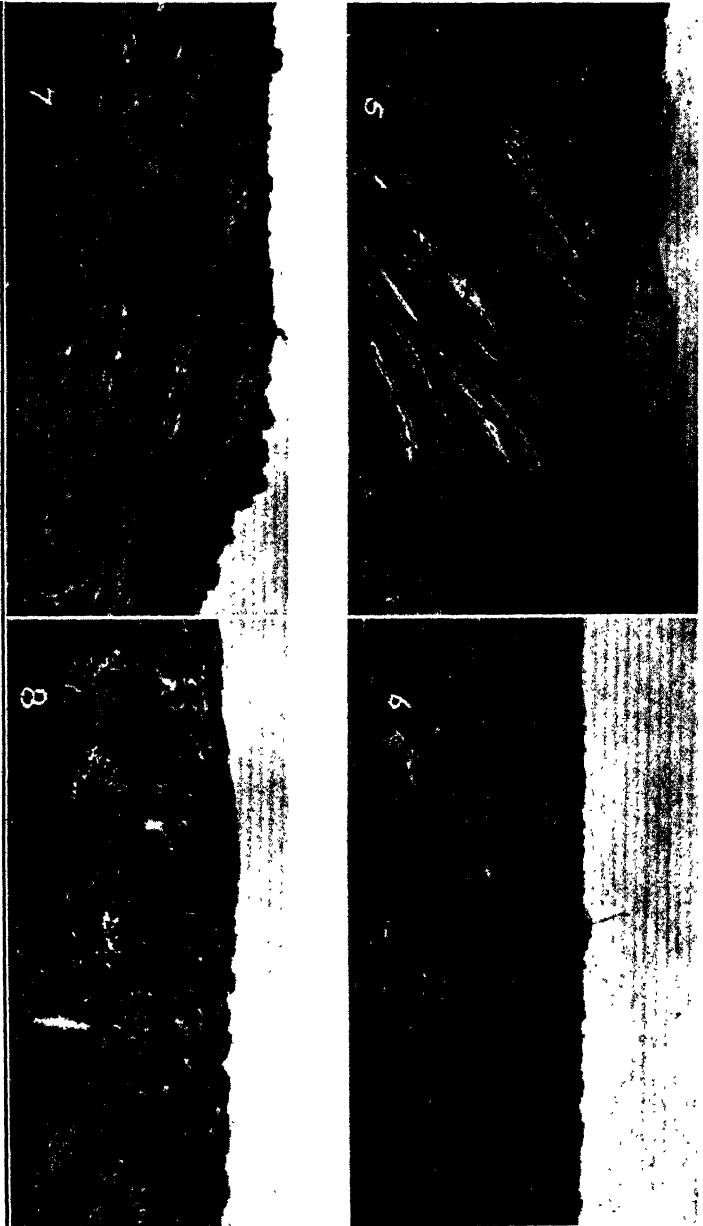
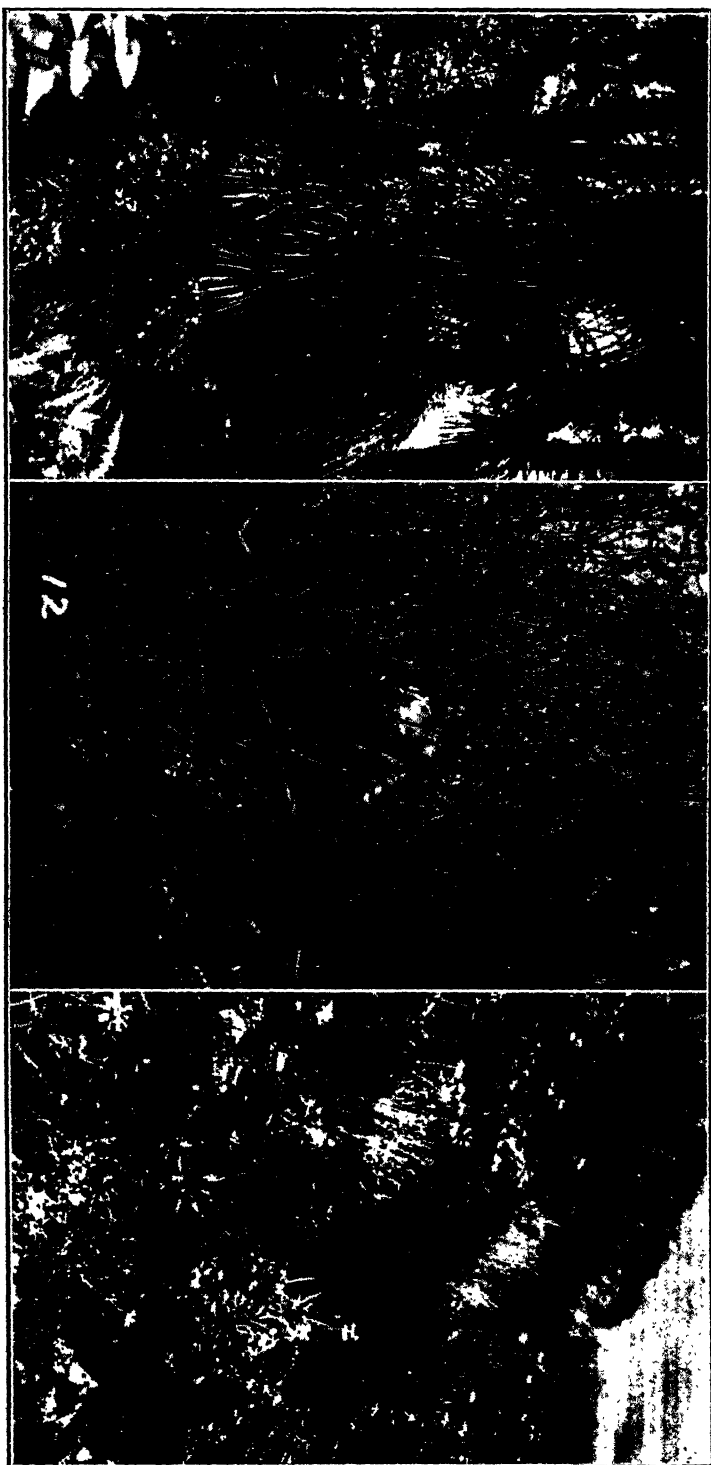


FIG. 5.—Wind-channelled tussock on the north-western slope of the high ridge north-east of Mt. Holdsworth.
 FIG. 6.—*Kauria rubra-Phyllocline Colensoi* association on top of wind-swept West Peak (near Mt. Hector) c. 1300 m. FIG. 7.—Prostrate growth of *Nothofagus Arbutifolia* and *Dracophyllum Triflorum* on the wind-swept north-western slope of a knob (c. 1100 m.) near Mt. Omega. Old trees are here only about 50 cm. high. FIG. 8.—*Dracophyllum-Sphagnum* bog on Mt. Omega.



FIG. 9.—Interior of *Olearia colensoi* scrub on western slope of Mt. Walopehu, c. 100 m. The scrub here is 2-3 m. high. FIG. 10.—Interior of forest in Ohau Valley (Western Area), c. 200 m. J. Nicholls, photo.

FIG. 11.—*Premeria banksii* climbing up the trunk of *Laurelia novae-zeelandiae*, Ohau Valley, c. 200 m. FIG. 12.—*Rhipogonum scandens* on transepts, Thirlea Valley (western side of Northern Area), c. 150 m. The ground is covered with dead leaves. FIG. 13.—Heath-field on Mt. Tukematawai (near Mt. Arere), c. 1450 m. The lower plants seen are *Crimbia spectabilis*, *Leucopneus leontopodium*, and *Dunthoria antarctica* var.



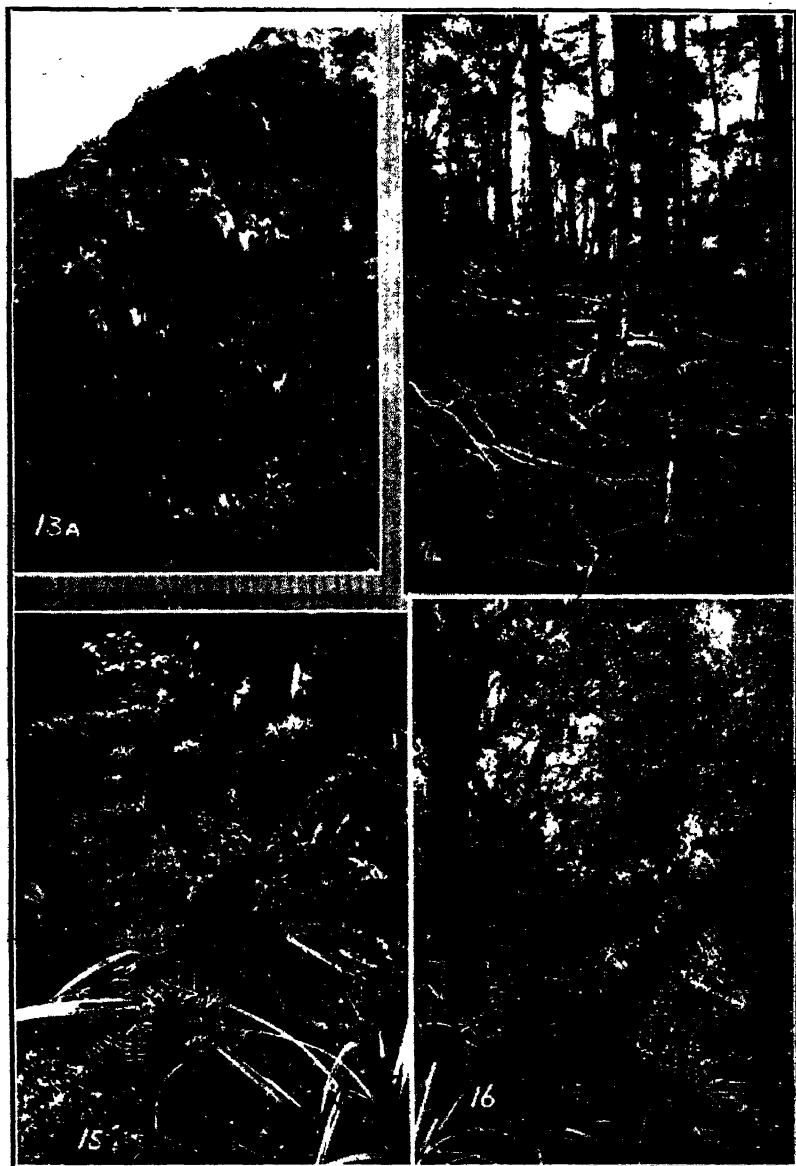


FIG. 13a.—*Usnea* sp. festooning *Nothofagus menziesii*. Mt. Holdsworth (Eastern Area), c. 1200 m. FIG. 14.—*Nothofagus fusca*-*Weinmannia racemosa* forest on eastern slope of Mt. Holdsworth (Eastern Area), c. 600 m. FIG. 15.—Bryophyte-clad young *Podocarpus hallii*. Near Field Hut (Western Area), c. 850 m. FIG. 16.—*Weinmannia racemosa*-*Nothofagus menziesii* forest on a western slope near Tematawai Hut (near Mt. Waitepehu), c. 200 m.

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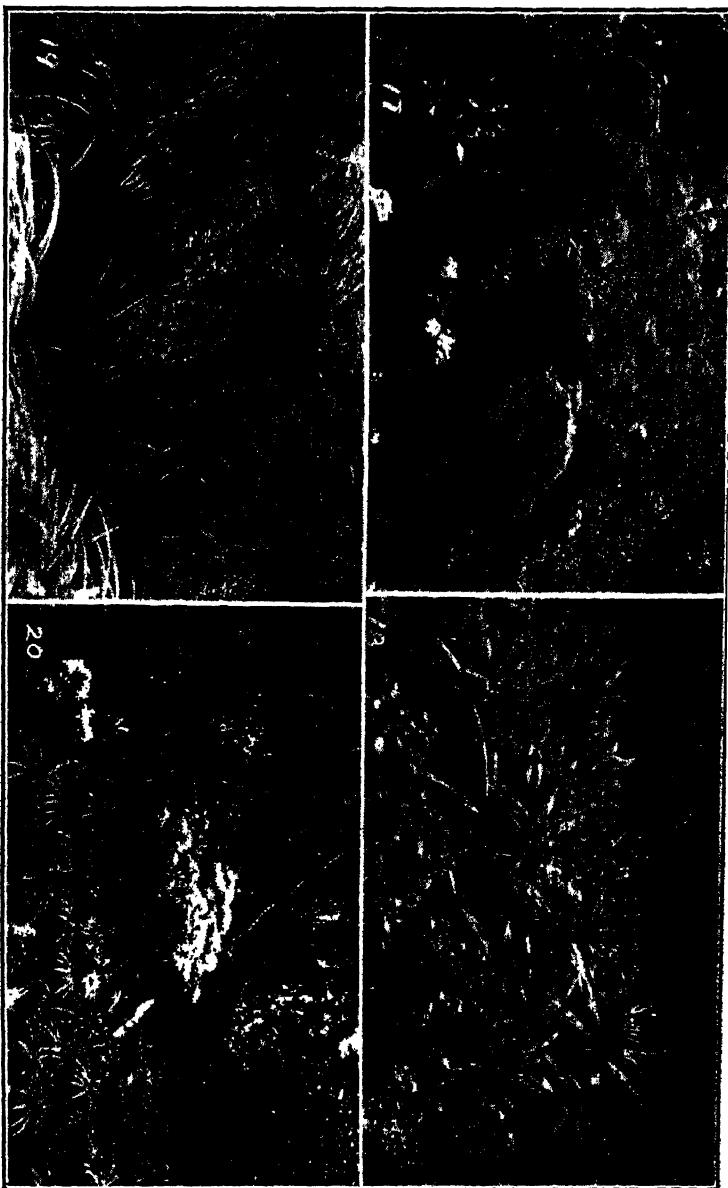


FIG. 17.—*Raoulia rubra-Phyllachne colensoi* association on wind-swept slope of Mt. Hector, c. 1500 m. FIG. 18.—*Cordylus indivisa* near Mt. Omega, c. 1000 m. The young leaves of the trees 1-2 m. high were attacked by deer during winter of 1932. All trees in the grove of some 30 are now dead. FIG. 19.—*Aciphylla colensoi* conspicuous in *Dactyloctenium aegyptium* tussock on Mt. Hector, etc., 1150 m. FIG. 20.—*Senecio kuhnii* in flower. Area, c. 600 m. *Gleichenia cunninghamii* in foreground; in centre *Senecio kuhnii* in flower.

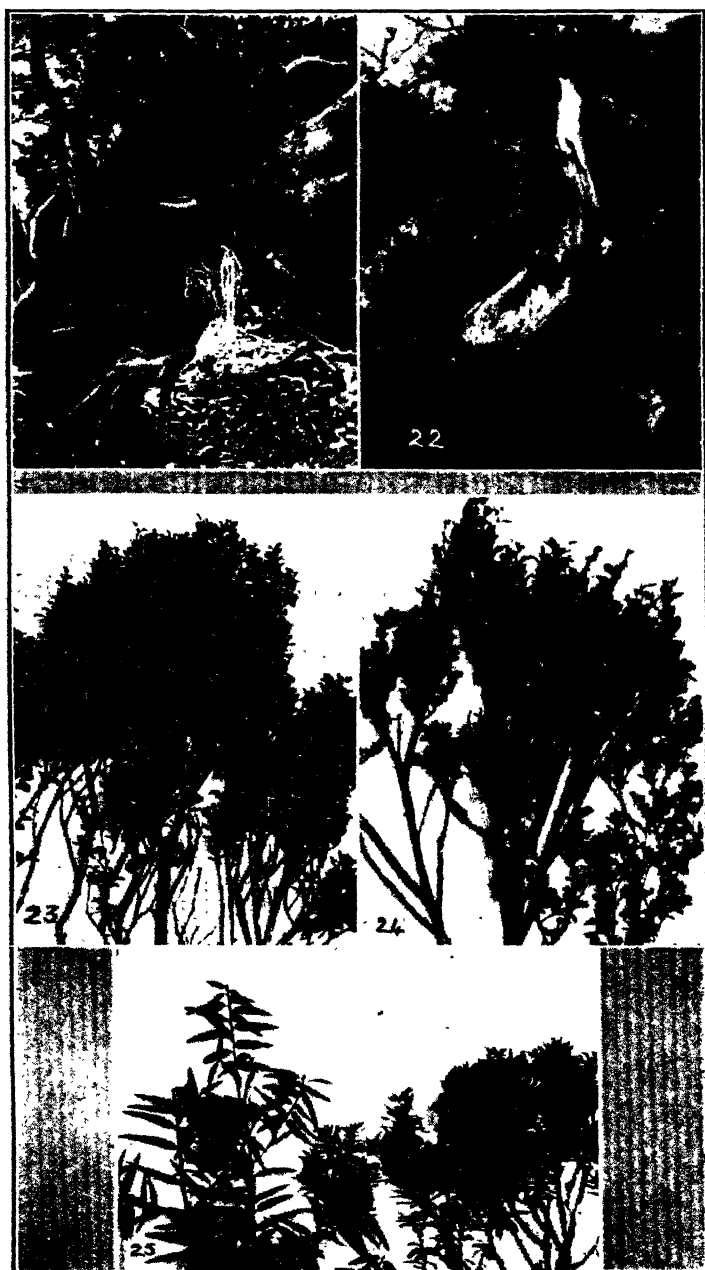


FIG. 21.—Aerial roots of *Griselinia lucida* encircling the trunk of *Corynocarpus laevigata*. Mukumuku Valley, Southern Area. FIG. 22.—*Griselinia littoralis* ringbarked by deer from 1 to 2 m. from the ground. FIG. 23.—Uppermost branches of *Nothofagus menziesii* from timber-line near Field Hut (western slope), Western Area, c. 900 m. FIG. 24.—Uppermost branches of *N. menziesii* from timber-line on eastern slope of Mt. Alpha, Eastern Area, c. 1200 m. The scale of the photographs 23 and 24 is identical (about $\times \frac{1}{2}$). FIG. 25.—*Podocarpus hallii* showing shade (left) and sun foliage (right). In scrub formation frequently only the sun foliage is prominently developed.

ABBREVIATIONS.

- A: Aston, 1910.
 B: Beddie, —.
 Bu: Buchanan, 1874.
 C: Cockayne, 1906.
 E: Elder, —.
 K: Kirk, 1899.
 M: Cheeseman, 1925.*
 O: Oliver (or Heine in O), 1935.
 P: Petrie, 1908.
 To: Townson, in M.
 Tr: Travers, in M.
 W: Aston, 1911.
 X: Not observed by B, E, or Z.
 Z: Zotov, —.
 oo: More than two collectors in M.
 * (Example: M—A! = collected by A, seen by Cheeseman and recorded for Tararuas in M).
- LWSubp: lower warm subpolar belt.
 UCTemp: upper cold temperate belt.
 LCTemp: lower cold temperate belt.
 CTemp: both U+L cold temperate b.
 UWTemp: upper warm temperate b.
 LWTemp: lower warm temperate b.
 WTemp: both U + L warm temperate belt.
 Temp: both cold and warm temperate belt.
- bog: \pm permanently wet open ground.
 ep: true epiphyte.
 fell: fellfield.
 forest: tall forest.
 herb: herb field.
 mead: meadow, tall tussock, etc.
 river: riverbed.
 rocks: rocks, e.g. in gorges or on peaks.
 scrub: cold temperate scrub.
 water: watercourse and river bank.
- dd: single dominant.
 d: co-dominant.
 pp: very plentiful.
 p: plentiful.
 cc: very common.
 c: common.
 ff: very frequent.
 f: frequent.
 rr: rather rare.
 r: rare or very rare.

PTERIDOPHYTA.

Hymenophyllaceae.

- Hymenophyllum rarum* Swartz.—A,Z. WTemp, ATA, ep, f.
H. sanguinolentum Swartz.—A,B,Z. Temp, ATA (CTemp, pp).
H. villosum Col.—Z. LCSubp, ATA, rock, f.
H. australe Willd.—Z. LWTemp, NTA, r.
H. pulcherrimum Col.—Z. LCTemp, WTA, r.
H. dilatatum Swartz.—A,B,Z. WTemp, ATA, p.
H. demissum Swartz.—A,B,Z. WTemp, LCTemp, ATA, p.
H. scabrum A. Rich.—A,B,Z. WTemp, ATA, ff.
H. flabellatum Lab.—A,X.
H. ferrugineum Colla.—A,B,Z. WTemp, ATA, rr.
H. tunbridgense Smith.—A,B,Z. WTemp, ATA, c.
H. peltatum Desv.—Z. c. 500 m., WTA (nr. Field Hut, only specimen).
H. multifidum Swartz.—A,B,Z. WTemp, ff, CTemp, pp-dd, ATA.
H. bivalve Swartz.—A,B,Z. WTemp, ATA, c.
Cardiomanes reniforme Presl.—A,B,Z. WTemp, ATA, pp.
Trichomanes Colensoi Presl.—M—Bu,X.
T. venosum Presl.—A,Z. WTemp, ATA, ep, ff.
T. strictum Presl.—A,X.

Cyatheaceae.

- Dicksonia squarrosa* Swartz.—A,B,Z. LWTemp, NTA, STA, ff.
Cyathea dealbata Swartz.—A,B,Z. LWTemp, ATA, c.
C. medullaris Swartz.—A,B,Z. LWTemp, ATA, c.
C. Smithii Hook. f.—A,B,Z. WTemp, LCTemp, ATA, pp.
C. Colensoi Domin.—A,Z. LWTemp, NTA, ETA, r.

Polypodiaceae.

- Cystopteris fragilis* Bernh.—M—Bu, X.
Polystichum vestitum Presl.—A, B, Z. CTemp, ATA, pp.
P. Richardi J. Smith.—A, B, Z. WTemp, ATA, cc.
P. cystostegia J. B. Armstr.—M—Bu, X.
P. hispidum J. Smith.—B, Z. WTemp, NTA, STA, rr.
P. adiantiforme J. Smith.—B, Z. WTemp, ATA, rr.
Dryopteris glabella C. Christensen.—A, B, Z. WTemp, ATA, f.
D. punctata C. Christensen.—A, Z. WTemp, WTA, rr.
D. pennigera C. Christensen.—A, B, Z. LWTemp, ATA, f.
Leptolepia novae-zealandiae Kuhn.—A, B, Z. LWTemp, ATA, rr.
Arthropteris tenella J. Smith.—B, Z. c. 100 m., nr. Manawatu Gorge, also nr. Porirua Harbour.
Lindsaya cuneata Swartz.—A, B, Z. WTemp, ATA, cc.
Asplenium flabellifolium Cav.—B. WTemp, Mt. Matthews (STA), r.
A. trichomanes Linn.—M—Bu, X.
A. adiantoides C. Christensen.—A, B, Z. LWTemp, ATA, ep, rr.
A. obtusatum Forst. f.—A, X.
A. lucidum Forst. f.—A, B, Z. LWTemp, ATA, c.
A. Hookerianum Col.—A, B, Z. WTemp, STA, f.
A. Colensoi Moore.—B. WTemp, STA, rr.
A. bulbiferum Forst. f.—B, Z. WTemp, ATA, c.
A. Richardi Hook. f.—M—Bu, —H. C. Field, X.
A. flaccidum Forst. f.—A, B, Z. WTemp, LCTemp, ATA, ep, c.
A. bulbiferum × *Hookerianum*.—B, Z.
A. bulbiferum × *flaccidum*.—B.
A. Hookerianum × *flaccidum*.—B.
Blechnum Patersoni Mett.—A, B, Z. WTemp, ATA, c.
B. discolor Keys.—A, B, Z. WTemp, LCTemp, ATA, d-dd.
B. vulcanicum Kuhn.—A, X.
B. lanceolatum Sturm.—A, B, Z. WTemp, ATA, gorges, ff.
B. Banksii Mett.—B. Cliffs, nr. coast, r.
B. penna-marina Kuhn.—A, B, Z. c. 900 m., Park Valley, c; also Big Hill (STA), rr.
P. procerum Labill.—A, B, Z. WTemp, CTemp, ATA, cc.
 There appear to be at least two jordanons.
B. minor Hook. f.—B, Z. LCTemp, ATA, cc. (UWTemp in Ruamahanga upper basin).
B. filiforme Ettingsh.—A, B, Z. WTemp, ATA, ep, c.
B. nigrum Metten.—Z. WTemp. WTA, on steep slopes, c.
B. fluviatile Salom.—A, B, Z. WTemp, ATA, ff.
Pellaea rotundifolia Hook.—B, Z. c. 100 m., vicinity of Manawatu Gorge, nr. Mt. Matthews, r.
H. tenuifolia Bernh.—B. LWTemp, STA, rr.
Hypolepis millefolium Hook.—A, M—A!—To, B. CTemp, STA, rare; Z. Park Valley, c. 1200 m., c.
H. distans Hook.—A, X.
Adiantum formosum R. Br.—Z. c. 100 m., Manawatu Gorge.
A. affine Willd.—A, B, Z. LWTemp, ATA, gorges, c.
Pteris tremula R. Br.—B, Z. WTemp, NTA, ETA, STA, ff.
P. macilentia A. Rich.—B, LWTemp, Mt. Matthews (STA), f.

- Histiopteris incisa* J. Smith.—A,B,Z. WTemp, ATA, c.
Pteridium aquilinum esculentum Hook. f.—A,B,Z. WTemp, ATA, c-dd.
Paesia scaberula Kuhn.—A,B,Z. WTemp, ATA, r (except on clearings).
Polypodium Billardieri C. Christensen.—A,B,Z. Temp, ATA, c.
P. b. var.—Z. CTemp, ATA, ff. Smaller and more slender than the former.
P. b. var.—Z. LWSubb, wet rocks, r. Much broader than the original species.
P. grammitidis R. Br.—A,B,Z. WTemp, ATA, c, on rocks.
P. pustulatum Forst. f.—B,Z. LWTemp, ATA, rr.
P. diversifolium Willd.—B,Z. WTemp, ATA, rocks or ep, ff.
Cyclophorus serpens C. Christensen.—A,B,Z. WTemp, LCTemp, ATA, rocks or ep, ff.

Gleicheniaceae.

- Gleichenia dicarpa* R. Br.—B,E. WTemp (?), STA, r.
G. alpina Hook. f.—B,E. c. 800 m., Mt. Kapakapanui and Mt. Orongorongo, r; E. c. 800 m., Mt. Kaiparoro, r.
G. Cunninghamii Heward.—A,B,E,Z. LCTemp, ATA, c-pp; UWTemp, f.

Schizaeaceae.

- Schizaea fistulosa* Labill.—E. c. 200 m., nr. Port Nicholson in manuka.

Osmundaceae.

- Leptopteris hymenophylloides* Presl.—A,B,Z. UWTemp, LCTemp, ATA, ff.
L. superba Presl.—A,B,Z. LCTemp, ATA, cc.

Ophioglossaceae.

- Ophioglossum coriaceum* A. Cunn.—E,B,Z. c. 300 m., Tauhere-nikau and lower Waiohine River flats, cc.
Botrychium australe millefolium (?) Plantl.—B,E. c. 300 m., Waiohine River flats (ETA), Muku-muku basin (STA), r.

Lycopodiaceae.

- Lycopodium australianum* Nerter.—B,E,Z. LWSubb, ATA, rr; also Mt. Matthews, c. 900 m.
L. varium R. Br.—B,E,Z. UWTemp, LCTemp, ATA, f.
L. Billardieri Spring.—B,E,Z. WTemp, ATA, f.
L. fastigiatum R. Br.—B,E,Z. Temp, ATA, r; LWSubb, c.
L. scariosum Forst. f.—B,E,Z. Temp, NTA, ETA, STA, c; WTA, rr.
L. volubile Forst. f.—A,B,Z. WTemp, ATA, r.
Tmesipteris tannensis Bernh.—A,B,E,Z. WTemp, ATA, ep, c.

SPERMATOPHYTES—GYMNOSPERMAE.

Pinaceae.

- Libocedrus doniana* Endl.—Bu,X.

Taxaceae.

- Podocarpus totara* D. Don.—B,E,P,Z. LWTemp, ATA, river, ff.
P. Hallii T. Kirk.—A,B,E,Z. UWTemp, LCTemp, ATA, cc.
P. nivalis Hook.—Bu,W—Bu,X. = epharmone *P. Hallii*?

- P. ferrugineus* D. Don.—B,E,P,Z. WTemp, LCTemp, pp-d.
P. spicatus R. Br.—A,B,E,Z. LWTemp, ATA, r; STA, c-dd.
P. dacrydioides A. Rich.—B,P,Z. LWTemp, ATA, river, r.
Dacrydium biforme Pilger.—E,Z. CTemp, NTA, c-d.
D. intermedium T. Kirk.—W,M—oo!, X = *D. biforme*?
D. cupressinum Soland.—B,E,P,Z. WTemp, ATA, c; NTA,
 WTA, dd.
Phyllocladus trichomanoides D. Don.—Bu,W—Bu,X. = *P.*
alpinus?
P. alpinus Hook. f.—E,Z. CTemp, NTA, pp-dd; nr. Mt. Renata
 (STA), isolated patch.

SPERMATOPHYTES—MONOCOTYLEDONAE.

Pandanaaceae.

- Freycinetia Banksii* A. Cunn.—B,E,P,Z. WTemp, ATA, c-pp.

Niadaceae.

- Potamogeton Cheesemanii* A. Bennett.—c. 300-400 m., ETA,
 STA, r.

Gramineae.

- Oplismenus undulatifolius* Beauv.—P,X.
Microlaena Colensoi Petrie.—P,W,M—Tr!, Z. LWSup, pp.
M. stipoides R. Br.—Z. LWTemp, Manawatu G., Muku-muku R.,
 Paekakariki cliffs, c, probably introduced into the loc.
M. avenacea Hook. f.—B,P,Z. WTemp, LCTemp, ATA, pp-d.
Hierochloa redolens R. Br.—P,Z. UCTemp, ATA, ff.
H. Fraseri Hook. f. var.—P,Z. UCTemp, ATA, f.
Echinopogon ovatus Beauv.—c. 100 m., Manawatu Gorge, r; Big
 Hill (STA), r.
Agrostis alpina Scop.—Z. LWSup, ATA, rr; CTemp, Waio-
 hine-iti V., c.
A. subulata Hook. f.—A,P,M—P!, X = preceding sp.?
A. muscosa T. Kirk.—P,W,M—oo!, Z. LWSup, rr.
A. Dyeri Petrie.—P,W,Z. LWSup, p.
A. parviflora R. Br.—Z. CTemp, ATA, in open places, ff; Mt.
 Waiopehu, pp.
Deyeuxia Forsteri Kunth.—B,P,Z. Temp, ATA, f. There appear
 to be several jordanons.
D. avenoides Buch.—B,Z. WTemp, Mt. Matthews, r.
D. setifolia Hook. f.—B,P,Z. CTemp (rr), LWSup, c.
D. quadriseta Benth.—A,Z. WTemp, NTA, ETA, STA, r.
Dichelachne crinita Hook. f.—A,B,Z. WTemp, NTA, ETA,
 STA, r.
Deschampsia tenella Petrie.—P,W—Tr, M—Tr!—P!, Z. LW-
 Sup, r; C Temp, Ruamahanga upp. basin, Waiohine-iti
 V., cc.
Trisetum antarcticum Trin.—B, P—A?, Z. CTemp, ETA, r;
 STA, ff.
T. Youngii Hook. f.—P—A?, W,M—Bu!—A!, Z. WTemp, NTA,
 r (probably introduced).
T. saxeticolum (Ckn. et Allan)—Z. Coastal cliffs, STA, ff.
Danthonia Cunninghamii Hook. f.—A,B,Z. CTemp, forest, pp.
D. Brunioides Hook. f.—B,Z. Mouth of Muku-muku R., c.

- D. antarctica* Hook. f. *flavescens* (Hack.)—B,Z. CTemp (except in forest), c; LWSUBP, dd.
- D.a. Cheesmanii* (Hack.) (?).—B,Z. WTemp, forest, STA, c.
- D.a.* var. (narrow-leaved).—B,Z. LWSUBP, pp-dd; UCTemp, Park V., p.
- D. Raoulii* Steud.—P,X. Probably includes *D. antarctica* and *D. Cunninghamii*.
- D. semiannularis* R. Br.—B,P,Z. WTemp, rr, probably introduced.
- D. nigricans* Petrie.—B,Z. CTemp, open places, pp.
- D. pilosa* R. Br. var.—B,Z. WTemp, STA, ff. possibly introduced.
- D. setacea* R. Br. *setifolia* (Hook. f.).—Z. NTA, WTemp, in gorges, CTemp, E. slopes of Mt. Ruapai cc-dd; Park V., p.
- D. nuda* Hook. f.—M—A!, X.
- Arundo conspicua* Forst. f.—A,B,Z. LWTemp, NTA, STA, introduced?
- A. fulvida* Buch.—B,Z. WTemp, ATA, ff.
- Triodia australis* Petrie.—P,W,X. Petrie's record of this S.I. species is doubtful, although there is a specimen in the Dominion Museum labelled "Mt. Holdsworth."
- Poa novae-zelandiae* Hack.—B,P,W,M—Bu!—Johns!, Z. LW-Subp, c.
- P. anceps* Forst. f.—B,P,Z. Temp, ATA, c. There appear to be two distinct jordanons, one found in WTemp, the other in CTemp.
- P. seticulmis* Petrie.—A,W,X. = epharmones of *P. anceps*?
- P. caespitosa* Forst. f.—B,P,Z. LWTemp, ETA, STA, f, on steep slopes, introduced?
- P. Colensoi* Hook. f.—B,P,Z. LCSUBP, pp.
- P. Kirkii* Buch.—B,W,M—Tr—Arnold,Z. LWSUBP, c.
- P. imbecilla* Forst. f.—B,P,W,Z. LWSUBP, c.
- P. n.sp.* (usu. placed in *P. imbecilla*).—Z. WTemp, STA, rr.
- Festuca multinodis* Petrie.—B,Z. Coastal cliffs (STA), cc.
- F.m.* var.—Z. Low rocks in Manawatu Gorge, pp.
- Agropyron scabrum* Beauv. (glaucous var.).—B,Z. Coastal cliffs and Manawatu Gorge, rr.

Cyperace.

- Mariscus ustulatus* C. B. Clarke.—B,Z. LWTemp, NTA, STA, f, introduced?
- Eleocharis Cunninghamii* Boeck.—A,X. = *E. acuta*?
- E. acuta* R. Br.—B,Z. WTemp, ATA, cut-off meanders, c.
- Isolepis* n.sp. (related to *I. basilearis* Hook. f.).—B,Z. LWTemp, Muku-muku basin, r. Possibly exotic to N.Z.
- I. aucklandica* Hook. f.—B,M—A!—P!,P,Z. CTemp, LWSUBP, cc.
- I. cernua* Roem. et Schult.—A,B,Z. WTemp, ATA, ff.
- I. inundata gracillima* (Cheesem.).—c. 600 m. High misty (STA), introduced.
- I. sulcata distigmatosa* (C. B. Clarke).—A,B,Z. LWTemp, ATA, water, ff.
- I. prolifer* R. Br.—A,B,Z. LWTemp, ATA, water, ff.

I. sulcataus × *prolifer*.

I. nodosa R. Br.—B,Z. Coastal, invades bare land.

Scirpus novae-zealandiae Col.—B. Muku-muku R. Introduced.

S. lacustris Linn.—B. Muku-muku R. Introduced?

Cyperus alpinus R. Br.—B,P,Z. CTemp, ATA, c, in open places, LWSubb, pp.

Schoenus pauciflorus Hook. f.—B,P,Z. LWSubb, pp.

Cladium Sinclairii Hook. f.—Manawatu Gorge, rocks, rr.

C. glomeratum, R. Br.—B. L.Ponui (STA).

C. Gunnii Hook. f.—B. L.Ponui (STA).

Lepidosperma australe Hook. f.—B,Z. WTemp, NTA, STA, r. Introduced.

Gahnia setifolia Hook. f.—B,P,Z. LWTemp, ATA, r.

G. pauciflora T. Kirk.—B,P,Z. WTemp, ATA, ff.

G.p. var. (possibly distinct sp.)—B,P,Z. CTemp, ATA, cc.

G. gahniaeformis A. A. Heller.—B. WTemp, STA, r.

Oreobolus strictus Berggr.—W,X.

O. pumilio R. Br.—Z. c. 660 m., Mt. Maunganui, ff.

O. pectinatus Hook. f.—B,P,Z. CTemp, LWSubb, pp.

Uncinia compacta R. Br.—P,W—Bu,M,Z. LWSubb, f. Possibly epharmane of *U. fusco-vaginata*.

U. fuco-vaginata Kukenth.—P,M—oo!Z. UCTemp, LWSubb, ATA, c.

U. purpurata Petrie.—W—P, X.

U. caespitosa Boott.—P,M—P!Z?

U. uncinata Kukenth.—B,P,Z. UWTemp, LCTemp, ATA, c; STA pp.

U.u. ferruginea C. B. Clarke.—Z. LWTemp, ATA, f; NTA, pp.

U. leptostachya Raoul.—B. WTemp, STA, r.

U. riparia R. Br.—B,Z. CTemp, ATA, cc.

U.r. Banksii C. B. Clarke.—Z. WTemp, ATA, ff.

U. strictissima Petrie.—B,Z. LWTemp, Muku-muku basin (STA), f.

U. rupestris Raoul.—P,W—Tr,Z. CTemp, ATA, cc.

U. filiformis Boott.—B,P,W,M—oo!, Z. LCTemp, ATA, cc.

Carex acicularis Boott.—P,W,M—P!Z. LWSubb, ff.

C. appressa R. Br.—B. WTemp, Mt. Matthews (STA), r.

C. secta Boott.—B,Z. LWTemp, ATA, river flats, rr.

C. Colensoi Boott.—Z. CTemp, Mt. Holdsworth (ETA), r.

C. subdola Boott.—B. c. 600 m., Mt. Orongorongo (STA), r.

C. ternaria Forst. f.—B,P,Z. LWTemp, ATA, rr.

C.t. gracilis Cheesem.—Z. Manawatu Gorge, r.

C. lucida Boott.—B,Z. WTemp, NTA, ETA, STA, r.

C. comans Berggr.—B,Z. WTemp, ETA, STA, rr.

C. dissista Sol.—B,P,Z. CTemp, ATA, ff.

C. monticola Kukenth.—B,Z. WTemp, LCTemp, ATA, c.

C. Solanderi Boott.—B,Z. LWTemp, Orongorongo and Muku-muku basin, rr.

C. semi-forsteri C. B. Clarke.—B. LWTemp, nr. Mt. Matthews, r.

Palmae.

Rhopalostylis sapida Wendl.—B,E,Z. LWTemp, ATA, ff.

Centrolepidaceae.

Gaimardia ciliata Hook. f.—E,P,M—P,Z. LWSubp, cc.

Juncaceae.

- Juncus pallidus* R. Br.—B,Z. LWTemp, ATA, river, r.
J. pauciflorus R. Br.—B,Z. LWTemp, ATA, river, r.
J. vaginatus R. Br.—B,Z. LWTemp, ATA, river, r.
J. polyanthemos Buchen.—B,Z. Temp, ATA, wet open places, ff.
J. luxurians Col.—B,Z. LWTemp, ATA, river, r.
J. pallidus × *vaginatus*.
J. pallidus × *polyanthemos*.
J. vaginatus × *polyanthemos*.
J. planifolius R. Br.—A,B,Z. WTemp, ATA, f. Two varieties, one chiefly in NTA, WTA, the other in ETA, STA.
J. caespiticus bracteatus Buchen.—A,B,Z. LWTemp. Mt. Matthews (STA), f.
J. antarcticus Hook. f.—B,E,P,W,Z. UCTemp, LWSubp, ATA, cc.
J. prismatocarpus R. Br.—Z. LWTemp, NTA, Tiritea and Kahuterawa riverbeds, r.
J. scheuchzeroides Gaud.—A,X.
J. novae-zealandiae Hook. f.—B,P,W,Z. CTemp, ATA, ff.
Luzula Colensoi Hook. f.—W—To,M—To!,X.
L. campestris DC.—A,B,M,P,Z.
L.c. picta Hook. f.—B,Z. WTemp, LCTemp, ATA, c.
L.c. australasica Buchen.—B,Z. CTemp, ATA, c.
L.c. floribunda Buchen.—B,Z. CTemp, ATA, water, f; LWSubp, cc.

Liliaceae.

- Rhipogonum scandens* Forst.—B,E,P,Z. WTemp, ATA; STA and other drier places, r-f, elsewhere up to 450 m. pp-dd.
Enargea parviflora Scottsberg.—B,E,P,Z. LCTemp, ATA, cc.
Cordyline Banksii Hook. f.—B,E,P,Z. WTemp, LCTemp, ATA, water, f.
C. australis Hook. f.—B,Z. LWTemp, nr. Manawatu Gorge, Muku-muku basin, f.
C. indivisa Steud.—B,E,P,Z. CTemp, ATA, ff.
Astelia linearis Hook. f.—B,E,P,Z. UCTemp, ATA, rr; LWSubp, p.
A. Solanderi A. Cunn. (= *Cunninghamii* Hook. f. of Manual).—B,E,P,Z. WTemp, LCTemp, ATA, pp.
A. Haastata Col.—B,E,P,Z. WTemp, ATA, ep, cc.
A. Cunninghamii × *Solanderi*.—Z.
A. nervosa Banks et Sol.—B,E,P,Z. CTemp, ATA, pp.
A. Cockaynei Cheesem.—B,E,Z. UCTemp, LWSubp, pp-dd.
Dianella intermedia Endl.—B,E,P,Z. WTemp, ATA, f.
Phormium tenax Forst.—A,X.
P. Colensoi Hook. f.—B,E,P,Z. CTemp, ATA, pp-dd; WTemp, in gorges and coastal cliffs, c.
P. Colensoi × *tenax*.—B,Z. on coastal cliffs, f.
Bulbinella Hookeri Benth.—B,E,P,Z. LWSubp, p.
Arthropodium candidum Raoul.—LWTemp, STA, ff.
Herpolirion novae-zelandiae Hook. f.—W,X.

Iridaceae.

- Libertia ixioides* Spreng.—B,E,P,Z. WTemp, ATA, rr.
L. (undescribed sp.).—B,E,Z. WTemp, STA, rr.
L. pulchella Spreng.—B,E,P,Z. LCTemp, ATA, pp; UWTemp,
 Ruamahanga and Mangatainoka basins, c.

Orchidaceae.

- Dendrobium Cunninghamii* Lindl.—B,E,P,Z. WTemp, ATA, ep,
 c.
Bulbophyllum pygmaeum Lindl.—B,E,Z. LWTemp, ATA, ep, rr.
Earina muconata Lindl.—B,E,P,Z. LWTemp, ATA, ep, rr.
E. autumnalis Hook. f.—A,B,E,Z. WTemp, ATA, ep, cc.
Sarochilus adversus Hook. f.—B,E,Z. LMTemp, ATA, ep, rr.
Thelymitra longifolia Forst. var.—B,E,Z. WTemp, STA, c.
T.l. var.—E,Z. WTemp, STA, r.
T. venosa R. Br.—B,E,Z. WTemp, STA, open pl., rr.
T. uniflora Hook. f.—B,P,Z. CTemp, ATA, open pl., c.
Orthoceras strictum R. Br.—A,E,Z. WTemp, ATA, rr.
Microtis unifolia Reichenbach.—B. WTemp, STA, r.
Prasophyllum Colensoi Hook. f.—B,E,P,Z. CTemp, ATA, bogs, f.
Pterostylis confertifolia Cockn. et Allan.—A,B,E,Z. UCTemp,
 ATA, r.
P. Banksii R. Br.—A,B,E,Z. LWTemp, STA, f.
P. graminea Hook. f.—A,B,E. WTemp, STA, r.
P. foliata Hook. f.—A,M—A!,E. WTemp, STA, r.
P. venosa Col.—E,M—To!,Z. UCTemp, LCSubb, NTA, ETA,
 WTA, rr.
P. trullifolia Hook. f.—E. LWTemp, STA, r-f.
P. barbata Lindl.—E. LWTemp, STA, r.
Acianthus Sinclairii Hook. f.—E. LWTemp, STA, r.
Cyrtostylis oblonga Hook. f.—A,E. LWTemp, STA, r.
Calochilus paludosus R. Br.—W—Atkinson,X.
Lyperanthus antarcticus Hook. f.—E,P,W,Z. UCTemp, ATA, f.
Caladenia minor Hook. f.—E,W. LWTemp, STA, rr.
C. bifolia Hook. f.—E,P,W,Z. UCTemp, ATA, c.
Chiloglottis cornuta Hook. f.—A,B,E,W. UWTemp, LCTemp,
 STA, rr.
Adenochilus gracilis Hook. f.—E,Z. UWTemp, Ruamahanga
 basin (NTA), ff.
Corysanthes oblonga Hook. f.—B,W—Phillips. LWTemp, STA,
 r.
C. rivularis Hook. f.—E. c. 400 m., Mangatainoka R., r.
C. rotundifolia Hook. f.—B. LWTemp, STA, r.
C. triloba Hook. f.—B,E,P,Z. LCTemp, ATA, ff.
C. macrantha Hook. f.—B,E,Z. WTemp, ATA, c.
Gastrodia sesamoides R. Br.—A,W,X.
G. Cunninghamii Hook. f.—B,E,P,Z. LWTemp, ATA, ff.

SPERMATOPHYTA—DICOTYLEDONAE.

Piperaceae.

- Macropiper excelsum* Miq.—A,B,E,Z. 0-100 m., NTA, STA, pp.
Peperomia Urvilleana A. Rich.—E,Z. c. 20 m. Tokomaru G., nr.
 Mt. Wainui, r.

Fagaceae.

- Nothofagus Menziesii* Oerst.—B,E,P,Z. UWTemp, Mangahou V. (NTA), ETA, cc; CTemp, ETA, WTA, STA, dd.
N. fusca Oerst.—B,E,P,Z. UWTemp, LCTemp, ATA, p-dd, but absent north of Mt. Mairakau.
N. truncata Cockayne.—B,E,Z. WTemp, ETA, f; STA, pp-dd.
N. Solandri Oerst.—B,E,P,Z. WTemp, ETA, ff; STA, pp-d; nr. Manawatu G. (NTA), r.
N. cliffortioides Oerst.—A,X.
N. Solandri \times *truncata* = \times *N. apiculata* (?).—B,E,P,Z. cc.

Moraceae.

- Paratrophis microphylla* Cockayne.—B,E,Z. LWTemp, NTA, ETA, STA, r.
P. opaca Britton.—M—A!,B,E,Z. LWTemp. STA, r; west slopes of Mt. Wainui, cc.

Urticaceae.

- Urtica ferox* Forst. f.—B,E,Z. LWTemp, NTA, STA, ff.
U. incisa Poir.—B,P,Z. LWTemp, ATA, ff.
Elatostema rugosum A. Cunn.—E,Z. LWTemp, NTA, water, pp.
Parietaria debilis Forst. f.—B,Z. LWTemp, NTA, STA, ff.
Ausaralina pusilla Gaud.—B,Z. LWTemp, Manawatu G., r; STA, r.

Proteaceae.

- Knightia excelsa* R. Br.—A,B,E,Z. WTemp, NTA, STA, cc; WTA, ETA, r.

Santalaceae.

- Mida salicifolia* A. Cunn.—E,Z. WTemp, NTA, p; WTA, rr.
M. myrtifolia A. Cunn.—B,Z. LWTemp, STA, r; Mt. Wainui, f.

Loranthaceae.

- Elytranthe Colensoi* Engl.—P,B. WTemp, ETA, STA, r.
E. tetrapetala Engl.—A,E,Z. WTemp, ETA, STA, f.
E. flavida Engl.—B. LWTemp, STA, r.
Loranthus micranthus Hook. f.—B,Z. LWTemp, ETA, STA, rr, c. 800 m., Mt. Mitre (ETA), single sp.
Tupeia antarctica Cham.—A,X.
Korthalsella salicornioides Van.—B,E,Z. LWTemp, STA, ff.
K. Lindsayi Engl.—B. LWTemp, Wainui-o-mata V., r.

Balanophoraceae.

- Dactylanthus Taylori* Hook. f.—A,M—A!,X.

Polygonaceae.

- Muehlenbeckia australis* Meissn.—A,B,E,Z. LWTemp, ATA, river, c.
M. Astoni Petrie.—B. nr. C. Turakirae, r.
M. complexa grandiflora H. Carse.—A,B,Z. LWTemp, ATA, c.
M.c. trilobata Cheesem.—B. LWTemp, STA, r.
M.c. microphylla Cockayne.—B. LWTemp, STA, coastal cliffs c.

Aizoaceae.

- Mesembryanthemum australe* Sol.—B,Z. Cliffs at C. Turakirae, f.
Tetragonia trigyna Banks et Sol.—B,E. LWTemp, nr. C. Turakirae, rr.

Portulacaceae

Claytonia australasica Hook. f.—B,C,E,P,W,Z. LWSubp, screes, cc.

Montia fontana Linn.—E,Z. LWSubp, water, pp.

Caryophyllaceae.

Stellaria parviflora Banks et Sol.—B,P,Z. Temp, NTA, ETA, STA, rr.

Colobanthus crassifolius Hook. f.—A,W,Z. LWSubsp, screes, f.

C. Muelleri T. Kirk.—B. Coastal cliffs, Cook Str, f.

Ranunculaceae.

Clematis indivisa Willd.—B,E,P,Z. WTemp, ATA, c.

C. hexasepala DC.—B,P. LWTemp, STA, r.

C. Colensoi rutaefolia Hook f.—B,E,Z. LWTemp, NTA, STA, rr.

C. foetida Raoul.—B,Z.—LWTemp, NTA, STA, f.

Ranunculus insignis Hook f.—B,E,K,M,P,W,Z. UCTemp, LW-Subp, ATA, water, p.

R. Monroi Hook. f.—K—Bu!, A—Bu, W—Bu, M—Bu!, X. = ep-harmones of *R. insignis*?

R. geraniifolius Hook. f.—K—Bu!—Arnold!, M—Bu!—Arn!—B,E,P,Z.

R.g. var. (deeply trilobed lvs.)—E,Z. LWSubp, herb, c.

R.g. var. (deeply several times trilobed).—E,Z. LWSubp, bog, c.

R. tenuicaulis Cheesem.—C,P,W—C,M—ool!, X?

R. hirtus Banks et Sol.—B,E,P,Z. CTemp, ATA, ff.

R. lappaceus Smith.—E,Z. UCTemp, LWSubp, Mt. Waingawa, Mt. Arête, Park V., ff-c.

R. rivularis Banks et Sol.—A,B,Z. LWTemp, ATA, r.

Caltha novae-zealandiae Hook. f.—B,E,M—ool!, P,Z. LCSubp, herb, bog, p.

Winteraceae.

Pseudowintera axillaris Dandy.—B,E,P,Z. WTemp, ATA, c-p.

P. colorata Dandy.—B,E,P,Z. LCTemp, ATA, pp.

Monimiaceae.

Hedycarya arborea Forst.—B,E,P,Z. WTemp, ATA, pp.

Laurelia novae-zealandiae A. Cunn.—B,E,P,Z. LWTemp, ff.

Lauraceae.

Beilschmiedia tawa Hook. f.—B,E,P,Z. WTemp, ATA, pp-dd.

Cruciferae.

Cardamine heterophylla O. E. Schultz.—E,P,Z. LWSubp, screes, c.

C.h. var.—B,Z. LWTemp, ATA, ff.

Lepidium oleraceum acutidentatum T. Kirk.—B. Cliffs, C. Tura-kirae, ff.

Droseraceae.

Drosera stenopetala Hook. f.—B,E,M—ool!, P,W,Z. UCTemp, LWSubp, bog, cc.

D. arcturi Hook.—M—Colenso!—A!—Olson!, X.

D. spathulata Lab.—P(?), X.

D. binata Lab.—A,E. LWTemp, STA, r; Otaki G. (WTA), r.

D. auriculata Baekh.—A,E. LWTemp, STA, in manuka, ff; Otaki G. (WTA), r.

Crassulaceae.

- Tillaea moschata* DC.—B. LWTemp, Mt. Matthews (STA), r.
T. debilis Col.—A,X.

Saxifragaceae.

- Carpodetus serratus* Forst.—B,E,P,Z. LWTemp, ATA, c.

Pittosporaceae.

- Pittosporum tenuifolium* Banks et Sol.—B,E,P,Z. WTemp, ATA, rr, exc. STA, c.
P. Colensoi Hook. f.—E. WTemp, Ruamahanga upper basin, r.
P. rigidum Hook. f.—K—Arnold!—Tr!, M—oo!, B,E,P,W,Z.
 CTemp, ATA, ff—cc.
P. cornifolium A. Cunn.—B,E,Z. LWTemp, ATA, f.
P. eugenoides A. Cunn.—A,B,E,Z. LWTemp, NTA, WTA, r;
 ETA, STA, ff.

Cunoniaceae.

- Weinmannia racemosa* Linn. f.—B,E,P,Z. WTemp, LCTemp, pp—dd.

Rosaceae.

- Rubus australis* Forst. f (not as in Cheeseman, 1925).—B,E,P,Z.
 LWTemp, ETA, STA, r.
R. cissoides A. Cunn. (not as in Cheeseman, 1925).—B,E,P,Z.
 WTemp, LCTemp, ATA ff.
R. schmidelioides A. Cunn. (not as in Cheeseman, 1925).—B,E,Z.
 LWTemp, ATA, r.
R. squarrosus Fritsch.—B,Z. Rocks at Manawatu G. and nr. C.
 Turakirae, r.
Geum parviflorum Sm.—B,E,P,W,Z. UCTemp, ATA, water, rr;
 LWSubp, scree, r.
Acaena novae-zealandiae T. Kirk.—P,X.
A. sanguisorbae Vahl.—B,E,P,Z. WTemp, ATA, river, pp.

Leguminosae.

- Carmichaelia australis* R. Br.—Z. 0–300 m., Mt. Wainui, c.
C. odorata Col.—B,E,P,W,Z. WTemp, ATA, gorges, pp.
C. flagelliformis Col.—B,E,P,Z. LWTemp, ATA, rocks, ff.
Edwardsia microphylla Salisb.—B,E,P,Z. LWTemp, NTA, STA,
 ff; ETA, rr; WTA, r.

Geraniaceae.

- Geranium microphyllum* Hook. f.—P,Z. UCTemp, ATA, r; Mt.
 Hector, 1500 m., r.

Oxalidaceae.

- Oxalis corniculata* Linn.—B,Z. LWTemp, STA, riverbed, ff.
 Probably introduced.
O. lactea Hook.—B,E,P,Z. LWSubp, water, c; WTemp, ETA,
 WTA, STA, riverbed, f.

Linaceae.

- Linum monogynum* Forst. f.—B,E,Z. Coastal cliffs, rr.

Rutaceae.

- Melicope ternata* Forst.—B,E,Z. 0–300 m., Mt. Wainui, c; nr. C.
 Turakirae, f.
M. simplex A. Cunn.—B,E,P,Z. LWTemp, ATA, rr; nr. Mana-
 watu G., Mt. Wainui, c.
M. simplex × *ternata*.—B.

Meliaceae.

Dysoxylum spectabile Hook. f.—B,E,P,Z. LWTemp, Western slopes of Mt. Wainui, pp.

Callitrichaceae.

Callitriche verna Linn.—Z. LWTemp, NTA, ff.

Coriariaceae.

Coriaria arborea Lindsay.—B,E,P,Z. LWTemp, ATA, c.

C. sarmentosa Forst. f.—B,Z. nr. *C. Turakirae*, r.

C. lurida, T. Kirk.—B,E,P,Z. UCTemp, ATA, screes, water, ff.

C. angustissima Hook f.—A,M—A! = *C. lurida*?

Corynocarpaceae.

Corynocarpus laevigatus Forst.—B,E,Z. 0-50 m., Muku-muku basin, c.

Icacinaeae.

Pennantia corymbosa Forst.—B,E,P,Z. LWTemp, ATA, rr-f.

Sapindaceae.

Alectryon excelsum Gaertn.—B,E,P,Z. 0-50 m., NTA, STA, ff.

Dodonaea viscosa Jacq.—B,E,Z. c. 80 m., Manawatu G., Wairongomai R., Silverstream (STA), r.

Rhamnaceae.

Discaria toumatou Raoul.—E,Z. nr. *C. Turakirae*, r.

Elaeocarpaceae.

Elaeocarpus dentatus Vahl.—B,E,P,Z. WTemp, ATA, ff.

E. Hookerianus Raoul.—B,E,P,Z. WTemp, LCTemp, ATA, r.

E. dentatus × *Hookerianus*.—B,E.

Aristotelia serrata W. R. B. Oliver.—B,E,P,Z. WTemp, ATA, pp; LCTemp, ATA, f.

A. fruticosa Hook. f.—A,B,E,Z. CTemp, ATA, f.

A. fruticosa × *serrata*.—Z.

Malvaceae.

Plagianthus divaricatus Forst.—B. 0-150 m., nr. *C. Turakirae*, r.

P. betulinus A. Cunn.—A,B,E,Z. 0-150 m., NTA, STA, f.

P. betulinus × *divaricatus*.—B.

Hokeria sexstylosa Col.—B,E,P,Z.

H.s. var.—E,Z. WTemp, ATA, water, ff.

H.s. var.—E,Z. UWTemp, CTemp, ATA, water, c; Waiohine-itī V., pp.

Violaceae.

Viola filicaulis Hook. f.—B,E,P,Z. CTemp, ATA, c.

V. Cunninghamii Hook. f.—B. CTemp, Mt. Matthews (STA), r.

Melicytus ramiflorus Forst.—B,E,P,Z. WTemp, ATA, cc-pp.

M. lanceolatus Hook. f.—B,E,P,W,Z. UWTemp, LCTemp, NTA, ETA, STA, rr-c.

M. micranthus Hook. f.—B. nr. Day's Bay (STA), r.

M. lanceolatus × *ramiflorus*.—B,Z.

Hymenanthera crassifolia Hook. f.—B,E. nr. *C. Turakirae*, f.

H. obovata T. Kirk.—B,E. nr. *C. Turakirae*, r.

Passifloraceae.

Tetrapathaea tetrandra Cheesem.—B,Z. c. 100 m., Manawatu G., Wairongomai basin, Mt. Wainui, f.

Thymelaeaceae.

- Pimelea longifolia* Banks et Sol.—A,B,E,W,Z. UCTemp, ATA, pp.
P. gnidia Willd.—P,M—P,W. = *P. longifolia*?; B,E,Z. UW-Temp, on ridges nr. Mt. Matthews (STA), rr.
Drapetes Dieffenbachii Hook.—B,E,P,Z. LWSup, c.

Myrtaceae.

- Leptospermum scoparium* Forst.—B,E,P,Z. WTemp, NTA, ETA, STA, r-ff.
L. ericoides A. Rich.—B,Z. LWTemp, Manawatu G., Muku-muku R., rr.
Metrosideros scandens Druce.—B,E,P,Z. WTemp, ATA, cc.
M. umbellata Cav. (?) var.—B,E,Z. LWTemp, NTA, ETA, STA, r.
M. carminea W. R. B. Oliver (= *M. diffusa* Sm.).—Bu, K—Mantell IX.
M. diffusa (Forst.) W. R. B. Oliver.—B,E,P,Z. LWTemp, NTA, STA, ff.
M. Colensoi Hook. f.—A,Z. LWTemp, NTA, STA, r.
M. robusta A. Cunn.—B,E,P,Z. WTemp, NTA, WTA, p-d; ETA, STA, rr-ff.
M. perforata A. Rich.—B,E,P,Z. LWTemp, ATA, f; STA, c.
Myrtus bullata Sol.—B,E,P,Z. LWTemp, ATA, r-ff.
M. obcordata Hook. f.—A,B,E. LWTemp, STA, r.
M. bullata × *obcordata*.—B.
M. pedunculata Hook. f.—B,E,P,Z. UWTemp, LCTemp, ATA, c.
Eugenia maire A. Cunn.—A,B,E,Z. LWTemp, ATA, r.

Onagraceae.

- Epilobium pallidiflorum* Sd.—A,X.
E. Billardierianum Ser.—B. LWTemp, Muku-muku basin (STA), r.
E. erectum Petrie.—B,P,Z. LWTemp, ATA, r.
E. junceum Soland.—B,P,Z. LWTemp, ATA, river, ff.
E. pubens A. Rich.—B,P,Z. WTemp, ATA, water, ff.
E. tenuipes Hook. f.—C,M—C,P,W—C,Z. Mangaterera R. (ETA), STA, r.
E. Hectori Haussk.—P?, M—P!X.
E. alsinoides A. Cunn.—B,P,Z. WTemp, ATA, r.
E. Cockayneianum Petrie.—A,B,K,M—ool,W,Z. UCTemp, ATA, f.
E. chloraeifolium Haussk.—A,B,K—Arnold,W,Z. UCTemp, ATA, rr.
E. insulare Haussk.—B,P. C. 50 m., L. Ponui (STA), r.
E. rotundifolium Forst. f.—B,P,Z. LWTemp, ATA, f.
E. linnaeoides Hook. f.—B,E,K—Bu,M—Bu—P,P,W—Bu,Z. CTemp, ATA, rr.
E. nummularifolium R. Cunn.—B,Z. LWTemp, ATA, r.
E. pedunculare A. Cunn.—B,E,P,Z. CTemp, ATA, c.
E. macropus Hook.—M—Bu,Z. LWSup, ff.
E. gracilipes T. Kirk.—P?—K,W—P,X.
E. microphyllum A. Rich.—B,K!, M—K,W—K,Z. LWTemp, STA, f.

E. glabellum Forst. f.—B,E,K,P,Z. CTemp, LWSubp, ATA, water, cc.

Fuchsia excorticata Linn. f.—B,E,P,Z. WTemp, LCTemp, ATA, p.

F. perscandens Ckne.—B. c. 50 m., Muku-muku R., r.

Haloragidaceae.

Haloragis erecta Schindler.—B,Z. LWTemp, ATA, r.

H. depressa Walp.—Z. c. 200 m., Mangatainoka R., river.

Myriophyllum propinquum A. Cunn.—Z. LWTemp, ETA, STA, river flats, r.

Gunnera monoica albocarpa T. Kirk.—B,Z. WTemp, STA, c.

G. strigosa Col.—B,E,P,Z. WTemp, ATA, water, p.

Araliaceae.

Nothopanax simplex Seem.—B,E,P,Z. CTemp, ATA, f.

N. Edgerleyi Harms.—B,E,P,Z. WTemp, ATA, f.

N. anomalum Seem.—B,E,P,Z. UWTemp, ATA, r; Orongorongo R., Ruamahanga R., north of Mt. Marima, f.

N. Sinclairii Seem.—B,E,M—P,P,Z. LCTemp, ATA, c.

N. Colensoi Seem (5-foliate).—B,E,K,P,Z. CTemp, ATA, pp.

N.c. (3-foliate).—E,Z. c. 1100 m., west slope of Mt. Jumbo, r.

N. arboreum Seem.—B,E,P,Z. WTemp, ATA, pp.

Schefflera digitata Forst.—B,E,P,Z. WTemp, ATA, pp.

Pseudopanax crassifolium C. Koch.—B,E,P,Z. WTemp, NTA, STA, f; ETA, WTA, r.

P. ferox T. Kirk.—B. nr. C. Turakirae, r.

Umbelliferae.

Hydrocotyle elongata A. Cunn.—B,P,Z. WTemp, ATA, rr.

H. dissecta Hook. f.—P,X.

H. americana Linn.—B. LWTemp, STA, rr.

H. novae-zealandiae D.C.—P,X.

H. moschata Forst. f.—B,Z. LWTemp, ATA, ff.

H. centella uniflora Nanfeldt.—B,Z. c. 500 m., Mt. Matthews (STA), r.

Schizeilema trifoliatum Domin.—B,M—P,Z. WTemp, ATA, river, rr; Mitre Flats, pp.

S. nitens Domin.—A?,X. = *S. trifoliatum*?

S. hydrocotyloides Domin.—M—To!,Z. LWSubp, screes, water, c; c. 900 m., Park V., f.

Oreomyrrhis andicola Endl.—B,E,P,Z. LWSubp, herb, cc; CTemp, water, f.

5 *Aciphylla Colensoi conspicua* T. Kirk.—B,E,P,Z. LWSubp, p.

A. squarrosa Forst.—B,E,P,Z. CTemp, ATA, water, ff.

A. Colensoi × *squarrosa*.—E.

A. intermedia Petrie.—A (1914), P (1912), M—oo!E,Z. LWSubp, rr.

A. Monroi Hook f.—P,W—P,X. = *A. intermedia*.

A. Lyallii Hook. f.—A?,X. = *A. intermedia*?

A. (undescribed sp.?).—Z. LWSubp, Mt. Mitre, Mt. Bannister, Mt. Waingawa, screes, ff.

Anisotome dissecta Cockayne.—Bu (*Ligusticum Lyallii*), K—Arnold!—Bu!, M—oo!, B,E,P,W,Z. LWSubp, herb, p-d.

A. aromatica Hook. f.—B,E,P,Z. LWSubp, fell, screes, p.

Angelica montana Cockayne.—K,X.

Cornaceae.

- Griselinia lucida* Forst. f.—B,E,Z. LWTemp, ATA, f.
G. littoralis Raoul.—B,E,P,Z. WTemp, LCTemp, ATA, c—pp.

Ericaceae.

- Gaultheria antipoda* Forst. f.—B,E,P,Z. WTemp, NTA, WTA, r; ETA, STA, f—c.
G. depressa Hook. f.—B,E,P,Z. UCTemp, ATA, f.
G. rupestris R. Br.—B,E,P,Z. CTemp, ATA, scrub, c.
G. antipoda × *rupestris*.—B,E,Z.

Epacridaceae.

- Pentachondra pumila* R. Br.—B,E,P,Z. LWSubp, herb, fell, pp; UCTemp, f.
Cyathodes acerosa R. Br.—B,E,P,Z. WTemp, ETA, STA, c.
C. empetrifolia Hook. f.—B,E,P,Z. CTemp, ATA, bog, ff.
C. Colensoi Hook. f.—M—A!, W,X.
C. pumila Hook. f.—W,X.
Leucopogon fasciculatus A. Rich.—B,E,P,Z. WTemp, NTA, rr; ETA, STA, c.
L. Fraseri A. Cunn.—B,E. nr. *C. Turakirae*, r.
Dracophyllum longifolium R. Br.—M—Bu!P!, Oliver (1928), P, X. Oliver's specimen so labelled in the Dominion Museum is juvenile *D. Urvilleanum*.
D. Urvilleanum A. Rich.—B,E,M, Oliver (1928), P,W,Z. CTemp, ATA (UCTemp, cc—dd; LCTemp, rr—c).
D.U. montanum Cheesem.—M,X. = epharmane of *D. Urvilleanum*?
D. uniflorum Hook. f.—P,W,X. = epharmane of *D. rosmarinifolium*?
D. rosmarinifolium R. Br.—B,E,M—Bu!—P!, P,W,Z. LWSubp, pp.

Myrsinaceae.

- Suttonia salicina* Hook. f.—B,E,P,Z. WTemp, ATA, f; LCTemp, ATA, pp.
S. australis A. Rich.—B,E,P,Z. LWTemp, ATA, rr.
S. divaricata Hook. f.—B,E,P,Z. CTemp, ATA, cc.
S. nummularia Hook. f.—C,E,M—oo!, P,W,Z. LWSubp, f.

Oleaceae.

- Olea Cunninghamii* Hook. f.—A,B,E. WTemp, STA, r.
O. lanceolata Hook. f.—A,B,Z. LWTemp, ATA, rr.
O. montana Hook. f.—B,E,M—oo!, P,Z. WTemp, STA, r.

Loganiaceae.

- Geniostoma ligustrifolium* A. Cunn.—B,E,Z. WTemp, ATA, r—f.

Gentianaceae.

- Gentiana Grisebachii* Hook. f.—A,B,Bu,E,M—Bu!, W,Z. CTemp, ATA, c.
G. patula Cheesem.—M—P!—To!, P,W,X. = epharmane of *G. bellidifolia*?
G. bellidifolia Hook. f.—B,E,P,W,Z. CTemp, LWSubp, ATA, c.
G. pleurogynoides Griseb. as in Hooker, 1864.—Bu,X.
Liparophyllum Gunnii Hook. f.—B,E,M—P!—A!, P,W,Z. LC-Subp, bog, cc.

Apocynaceae.

Parsonsia heterophylla A. Cunn.—B,E,P,Z. WTemp, ATA, water, rr.

P. capsularis R. Br.—B,E,P,Z. LWTemp, ATA, water, r.

P. capsularis × *heterophylla*.—B,Z.

Convolvulaceae.

Calystegia tuguriorum R. Br.—B,Z. 0-80 m., nr. Manawatu G., Muku-muku R., f.

Dichondra repens Forst.—B,Z. c. 100 m., nr. C. Turakirae, r.

Boraginaceae.

Myosotis Forsteri Lehm.—B,E,Z. Temp, ATA, water, rr.

M. Astoni Cheesem.—A,M—To!—A!,W,X. (Mt. Holdsworth)

Solanaceae.

Solanum aviculare Forst. f.—A,B,E,Z. LWTemp, NTA, STA, rr.

Scrophulariaceae.

Jovellana repens Kranzl.—B,C,E,M—C—P(?),W,Z. WTemp, NTA, r; STA, f.

Mazus radicans Cheesem.—Bu,W—Colenso,X.

Hebe salicifolia Pennell.—B,E,P,Z. Temp, ATA, water, pp..

There are a number of distinct but interhybridising jordanons. The following is only an approximate summary.

H.s. Atkinsonii Cockayne.—B,E,Z. LWTemp, STA, f-c.

H.s. longiracemosa Cockayne.—Z. LWTemp, NTA, c.

H.s. angustissima Cockayne.—E,Z. WTemp, NTA, WTA, f-c.

H.s. stricta Hook. f.—E,Z. WTemp, ETA, c.

H.s. (?) paludosa Cockayne.—E,Z. CTemp, ATA, cc.

H.s. var.—E,Z. Manawatu G., Otaki G., rocks, c.

H. parviflora Ckn. et Allan.—B,E,Z. LWTemp, STA, f.

H. laevis Ckn. et Allan.—B,Bu,P,W,M—Bu!—P,Z. c. 1200 m., Mt. Dinnan, nr. Mt. Matthews, r.

H. evenosa Ckn. et Allan.—B,E,M—P!—A!,Z. CTemp, ATA, ff-cc.

H. buxifolia Ckn. et Allan.—B,E,M,P,W,Z. UCTemp, WTA, ETA, STA, f.

H. Astoni Ckn. et Allan.—B,Bu(*V. tetragona*),E,M,P,W,Z. LW-Subp, cc.

Veronica catarractae Forst. f.—A,B,E,M,P,W,Z.

V.c. lanceolata Hook. f.—B,E,Z. LWTemp, NTA, ETA, STA, water, c-p; WTA, r.

V.c. diffusa Hook. f.—B,E,Z. UWTemp, C Temp, ATA, rocks, c-p.

V. Lyallii Hook. f.—B,Z. LWTemp, Manawatu G., Muku-muku R., r.

Ourisia macrophylla Hook.—B,E,P,Z. CTemp, ATA, water, f.

O.m. var (smaller than the preceding).—B,E,Z. CTemp, ETA, STA, water, f.

O. Colensoi Hook. f.—B,M—P!,P,W,Z. CTemp, STA, water, rr.

O. caespitosa Hook. f.—E,M—ool,P,W,Z. LWSubp, r.

Euphrasia cuneata Forst. f.—B,E,P,Z. CTemp, ATA, scrub, p.

- E. revoluta* Hook. f.—B,E,M—Bu!—P!,P,W,Z. CWSUBP, herb, f.
E. zealandica Wettst.—A,M—P—A!,W,X. = epharmone of *E. revoluta*?

Gesneriaceae.

- Rhabdothamnus Solandri* A. Cunn.—B,Z. LWTemp, NTA, STA, r.

Myoporaceae.

- Myoporum laetum* Forst. f.—B,E,Z. Manawatu G., west slopes of Mt. Wainui, cliffs along Cook Str., cc.

Plantaginaceae.

- Plantago Raoulli* Deene.—A,B,P,Z. WTemp, STA, r.
P. Brownii Rapin.—A,B,E,M—oo!,W—Bu,Z. LWSUBP, cc.
P. lanigera Hook. f.—E,Z. LWSUBP, Mt. Arête and surrounding peaks, f.
P. Brownii × *lanigera*.—Z.
P. uniflora Hook. f.—E,M—oo!P,W,Z. LWSUBP, bog, ff.

Rubiaceae.

- Coprosma australis* Robinson.—B,E,O,P,Z. WTemp, LCTemp, ATA, cc.
C. lucida Forst. f.—B,E,O,P,Z. WTemp, LCTemp, ATA, ff.
C. retusa Hook. f.—B,E,O,Z. Coastal cliffs, Cook Str. and Mt. Wainui.
C. robusta Raoul.—B,E,P,Z. WTemp, ATA, rr-ff.
C. tenuifolia Cheesem.—Z. WTemp, nr. Manawatu G., upper Ruamahanga basin (NTA), r.
C. rotundifolia A. Cunn.—B,E,O,Z. LWTemp, NTA, STA, ff.
C. areolata Cheesem.—B,E,Z. 0-50 m., nr. Cook Str., r.
C. tenuicaulis Hook. f.—B,E,Z. LWTemp, STA, f.
C. rhamnoides A. Cunn.—B,E,O,P,Z. WTemp, NTA, ETA, STA, rr-cc; WTA, r.
C. parviflora Hook. f.—A,B,E,O,Z. CTemp, ATA, cc.
C.p. (recurving branches).—E,Z. ETA, f., Mt. Waiopahu.
C.p. (fruit crimson).—Z. NTA, c.
C.p. (fruit white).—B,E,Z. ATA, f-cc.
C.p. (fruit yellow).—B,Z. STA, rr.
 × *C. Buchananii* T. Kirk.—B. nr. C. Turakirae, r.
C. crassifolia Col.—B. nr. C. Turakirae, r.
C. rigida Cheesem.—B. c. 50 m., Mt. Matthews, r.
C. rubra Petrie.—A,B,M—A!,W—P. LWTemp, ETA, STA, r.
C. brunnea Cockayne.—Z. c. 210 m., Mangatainoka, river, r.
C. rugosa Cheesem.—B,E,Z. CTemp, Park V., Mt. Dennen, nr. Mt. Matthews, Ruamahanga basin, r.
C. propinqua A. Cunn.—B,E,Z. LWTemp, nr. Cook Str., r.
C. propinqua × *robusta*.—B.
C. foetidissima Forst.—B,E,O,P,Z. CTemp, ATA, pp.
C. Colensoi Hook. f.—B,E,K—Budden!,M,O,P,W,Z. CTemp, ATA, pp.
C. Banksii Petrie.—B,E,M—Bu—P!,O,P,Z. WTemp, ETA, pp; NTA, STA, rr.
C. Colensoi × *Banksii*.—A (1927),O,Z. These are really two of the series of distinct varieties of the same species.

- C. Colensoi* \times *foetidissima*.—Allan (1927), O, X.
C. Banksii \times *foetidissima*.—Allan (1927), O, X.
C. pseudocuneata W. R. B. Oliver.—B, E, O, P, W, Z. CTemp, ATA, pp.
C. microcarpa Hook. f.—A, B, E, M—P!, O, W, Z. LWTemp, ETA, STA, rr.
C. depressa Col.—B, E, M—P!, O, P, W, Z. UCTemp, ATA, f.
C. repens Hook. f.—B, E, O, P, W, Z. LWSubp, herb, bog, pp.
Nertera depressa Banks et Sol.—P, Z. CTemp, ATA, f.
N. dichondraefolia Hook. f.—B, P, Z. WTemp, ATA, rr.
N. setulosa Hook. f.—B, Z. CTemp, ATA, rr-c.
Galium umbrosum Sol.—B. WTemp, STA, r.

Caprifoliaceae.

- Alseuosmia macrophylla* A. Cunn (?).—B, E, P, W—P, Z. WTemp, LCTemp, ATA, f-c.

Campanulaceae.

- Pratia angulata* Hook. f.—B, E, P, Z. WTemp, ATA, river, c.
P. perpusilla Hook. f.—Z. Low rocks, Manawatu Gorge, r.
Wahlenbergia gracilis Schrad.—A, B, E, Z. WTemp, ATA, water, r.
W. albomarginata Hook.—E, Z. LWSubp, ETA, r.

Stylidiaceae.

- Donatia novae-zealandiae* Hook. f.—A, B, M—To!, W—To!. LW-Subp, Field Pk., r.
Phyllachne Colensoi Berggr.—B, Bu, E, P, Z. LWSubp, fell, p.
Forstera Bidwillii Hook. f.—E, P(?), Z. UCTemp, LWSubp, ATA, bog, c.
F. tenella Hook. f.—P, X.

Compositae.

- Lagenophora pumila* Cheesem.—A, B, E, Z. WTemp, cleared forest, c.
L. petiolata Hook. f.—B, E, K, P, Z. WTemp, cleared forest, c.
Brachycome Sinclairii Hook. f.—E, K, Z. c. 900 m., Waiohine-iti V., rr.
Olearia Colensoi Hook. f.—B, Bu, E, K, M, P, W, Z. CTemp, ATA, pp-dd, LWSubp, water, f. There are two jordalous: one with purple flowers, the other with yellow.
O. arborescens Cockayne et R. M. Laing.—B, E, P, Z. CTemp, ATA, cc.
O. ilicifolia Hook. f.—Bu, E, Z. CTemp, ATA, rr.
O. rani Druce.—B, E, Z. WTemp, ATA, f-c.
O. r. var. (lvs. orbicular).—Z. LWTemp, Mt. Wainui, f.
O. lacunosa Hook. f.—B, Bu, E, K, M, oo!, P, W, Z. UCTemp, cc.
O. arborescens \times *lacunosa*.—B, Bu, E, P, Z.
O. paniculata Cheesem.—B, E, Z. LWTemp, STA, r-f.
O. virgata Hook. f.—E, Z. LWTemp, NTA, r.
O. Solandri Hook. f.—B, E, Z. LWTemp, STA, r.
Celmisia densiflora Hook. f.—Bu, K—Bu, X.
C. incana Hook. f.—K, M—Bu, W—Bu, X.
C. hieracifolia Hook. f.—A, B, E, C(?), M—A!—P!, P, Z. LWSubp, herb, cc.

- C.h. oblonga* T. Kirk.—B,E,Z. LWSubp, fell, bog, south of Mt. Hector, c.
- C. spectabilis* Hook. f.—B,E,P,W,Z. LWSubp, herb, pp-d.
- C. coriacea* Hook. f.—K—Bu,M—Bu,W—Bu,X.
- C. gracileta* Hook. f.—A,B,E,Z. UCTemp, Mt. Kaipororo, Mt. Oriwa Lake-Hollow, p; ETA, r.
- C. graminifolia* Hook. f.—M—To!,X. = *C. gracileta*?
- C. hectori* Hook. f.—Bu,K—Budden!,M—K,W—Budden,X.
- Vittadinia australis* A. Rich.—B,E,Z. WTemp, STA, f.
- Gnaphalium Lyallii* Hook. f.—B,K!,M—K,W—K,Z. WTemp, STA, rr.
- G. trinerve* Forst. F.—E,K!,M—K!,W—K,Z. c. 900 m., Park R., c.
- G. kerianse* A. Cunn.—B,E,P,Z. WTemp, ATA, water, cc.
- G. kerianse* × *Helichrysum bellidioides*.—B,Z.
- G. subrigidum* Col.—Z. LWTemp, NTA, calcareous mudstones, r.
- G. Traversii* Hook. f.—A,B,E,M—oo!,P,W,Z. CTemp, ATA, f.
- G. luteo-album* Linn.—A,B,E,Z. WTemp, water, rr.
- G. japonicum* Thunb.—Z. WTemp, ATA, river, r.
- G. collinum* Lab.—B,Z. WTemp, ATA, river, rr.
- Raoulia rubra* Buch.—B,E,Bu(1882),K,M—Bu!,P,W,Z. LW-Subp, fell, rocks, pp-dd.
- R. mammillaris* Hook. f.—Bu,X. = *R. rubra*.
- R. Loganii* Cheesem. — A,B,Bu(1882),E,M—oo!,P,W,Z. LW-Subp, r.
- R. grandiflora* Hook. f.—B,E,P,W,Z. LWSubp, fell, cc.
- R.g. fasciculata* Cheesem.—Bu(1877),M—Tr!,K—Tr!,W—Tr!,X.
- R. glabra* Hook. f.—A,B,E,K,M—Bu—A!,W,Z. WTemp, STA, rr.
- R. australis* Hook. f.—B,E,Z. nr. Cook St., screes, p.
- R. tenuicaulis* Hook. f.—B,E,Z. WTemp, ATA, river, c.
- R.t. pusilla* T. Kirk.—B,E,K,Z. WTemp, ATA, river, p.
- Leucogenes leontopodium* Beauverd.—B,E,K.Budden!—To!,M,P,W,Z. LWSubp, herb, pp.
- Helichrysum bellidioides* Willd.—A,B,E,P,Z. CTemp, water, c; LWSubp, herb, f.
- H. filicaule* Hook. f.—B,P,Z. WTemp, ATA, open pl., r.
- H. glomeratum* Benth. et Hook. f.—A,B,E,Z. NTA, ETA, STA, f-c.
- Cassinia leptophylla* R. Br.—B,E,Z. WTemp, ETA, STA, f. Possibly introduced.
- C. Vauvilliersii* Hook. f.—B,E,Z. LWSubp, ETA, rr; east slope of Mt. Waingawa, c. 800 m.
- Craspedia uniflora* Forst. f.—A,B,E,Z. WTemp, ETA, STA, r-rr.
- Cotula pyrethrifolia* Hook. f.—B,M—A!—P!,P,Z. LWSubp, water, rr.
- C. squalida* Hook. f.—B,Z. LWTemp, ATA, river, r.
- Abrotanella pusilla* Hook. f.—B,E,M—oo!,P,W,Z. LWSubp, bog, cc.
- Erechtites prenanthoides* DC.—A,B,Z. WTemp, ATA, rr.
- E. arguata* DC.—A,Z. LWTemp, NTA, ETA, r. Introduced?
- E. scaberula* Hook. f.—B. LWTemp, nr. Mt. Matthews (STA), r.

- E. quadridentata* DC.—Z. c. 80 m., Manawatu G., rocks, r.
Brachyglottis repanda Forst.—B,E,P,Z. WTemp, ATA, water, pp.
Senecio lagopus Raoul.—B,E,P,Z. LWSubp, water, cc.
S. laetus Forst. f.—E. c. 400 m., Cross Ck. and Tapokopoko Ck., STA, r. Probably introduced.
S. Solandri Allan (1935).—B,E,P,Z. CTemp, ATA, water, cc.
S. Kirkii Hook. f.—B,E,P,Z. WTemp, ATA, c; WTA, pp; LCTemp, f.
S. Greyi Hook. f.—B,E,Z. LWTemp, Muku-muku basin (STA), p.
S. Adamsii Cheesem.—M—Toi, W, X. c. 1200 m., Mt. Holdsworth, only one specimen reported.
S. elaeagnifolius Hook. f.—B,E,P,Z. CTemp, ATA, c—pp.
S.e. var.—B,E,Z. CTemp, Mt. Matthews and nearby peaks, pp.
S. Bidwillii Hook f.—B,Bu,E,K—oo,P,Z. LWSubp, cc.

BRYOPHYTA—MUSCI.

V. D. ZOTOV and G. O. K. SAINSBURY.

Unlike higher plants, mosses do not lend themselves readily to field identification on account of their small size. Since microscopic examination is necessary in the majority of cases, listing of species directly in the field as one traverses the country is practically impossible. Further, more rare and more minute species are easily missed unless a careful search is made for them. Considering the extent of the country covered and the nature of the species, it will be seen that the list must necessarily be somewhat incomplete and the information on the distribution rather meagre. It might be stated, however, that a number of representative localities in each area as determined for the higher plants was thoroughly examined. In all cases where only a few specimens were collected numbers are given in the list referring to the specimens deposited in the herbarium of the Plant Research Bureau. The arrangement of families is that of Dixon (Verdoorn, 1932), while that of genera and species is alphabetical.

Sphagnaceae.

- Sphagnum irritans* Warnst.—UCTemp, LWSubp, ATA.
S. Kirkii Warnst.—7138, Orongorongo R., c. 600 m.
S. linguaefolium Warnst.—7447, 7450, Mt. Hector, c. 1400 m.
S. otagoense Warnst.—Mt. Omega, c. 1100 m. (reported by L. B. Moore).
S. subbicolor Hampe.—6614, Mt. Oriwa, c. 900 m.

Andreaeaceae.

- Andreaea acuminata* Mitt.—7384, Mt. Hector, c. 1400 m.
A. nitida H. f. and W.—7668, 7651, Mt. Hector, c. 1400 m.
A. rupestris Hedw.—6669, Te Matawai Hut, also Field Hut, c. 900 m.; LWSubp.
A. subulata Harv.—7425, Mt. Hector, c. 1300 m.

Colomniaceae.

- Colomna laetum* H. f. and W.—6858, Tiritea R., c. 400 m.

Dicranaceae.

- Dicranum superba* Grev.—WTemp, ATA.

Polytrichaceae.

Catharinaea Muelleri Hampe and C. M.—9160, 9161, Ruamahanga R., c. 320 m.

Oligotrichum tenuirostre (Hook.) Jaeg.—LCTemp, ATA.

Psilopalmum australe (H. f. and W.) Jaeg.—7392, nr. Field Hut, c. 1000 m.

P. Belli Broth.—6749, Mt. Hector, c. 1400 m. (coll. L. B. Moore).

P. crispulum (H. f. and W.) Jaeg.—LCTemp, ATA.

Pogonatum subulatum (Menz.) Brid.—4769, Tiritea R., c. 110 m.

Polytrichum commune Hedw.—6622, Mt. Oriwa, c. 900 m.

P. formosum Hedw.—nr. Alpha Hut, c. 1100 m. (reported by L. B. Moore).

P. juniperinum Willd.—WTemp, ATA.

Polytrichadelphus magellanicus Mitt.—Temp, ATA.

Fissidentaceae.

Fissidens adiantoides Hedw.—7593, nr. Field Hut, c. 850 m.

F. asplenioides (Sw.) Hedw.—LWTemp, ATA; 7593, Field Hut, c. 900 m.

F. campyloneurus C. M. and Beck.—6854, Tiritea R., c. 400 m.

F. dealbatus H. f. and W.—6869, etc., Tiritea R., c. 400 m.; 7536, nr. Field Hut, c. 850 m.

F. leptocladus C. M. and Rodway.—Manawatu Gorge, c. 150 m.

F. oblongifolius H. f. and W.—LWTemp, NTA.

F. pallidus H. f. and W.—7538, nr. Field Hut, c. 750 m.

F. rigidulus H. f. and W.—Temp, ATA.

Grimmiaceae.

Grimmia apocarpa Hedw.—7641, nr. Mt. Hector, c. 1200 m.; 7199, Wairongomai R., c. 500 m.

Racomitrium crispulum (H. f. and W.) H. f. and W.—UWTemp to LWSubp, ATA.

R. lanuginosum (Hedw.) Brid.—CTemp, LWSubp, ATA.

R. ptychophyllum Mitt.—7445, Mt. Hector, c. 1500 m.

Dicranaceae.

Blindia magellanica Sch. and C. M.—7437, Mt. Hector, c. 1300 m.

B. tenuifolia (H. f. and W.) Mitt.—7431, 7435, Mt. Hector, c. 1300 m.

Campylopodium euphorocladium (C. M.) Besch.—7395, 7435, nr. Field Hut, c. 1000 m.

Campylopus appressifolius Mitt.—6676, Te Matawai Hut, c. 900 m.

C. arboricola Card. and Dixon.—UWTemp, LCTemp, NTA, WTA.

C. clavatus (R. Br.) H. f. and W.—UCTemp, LWSubp, WTA.

C. introflexus (Hedw.) Mitt.—WTemp, LCTemp, ATA.

C. torquatus Mitt.—LWTemp, NTA.

Ceratodon purpureus Brid.—Temp, LWSubp, ATA.

Dicranella sp.—7645, nr. Mt. Hector, c. 1300 m.

Dicranoloma Billardieri (Schwaegr.) Par.—Temp, ATA.

D. cylindropyxis (C. M.) Dixon.—Temp, ATA.

D. Menziesii (H. f. and W.) Par.—WTemp, LCTemp, ATA.

D. m. rigidum (H. f. and W.) Par.—WTemp, ATA.

D. plurisetum (C. M.) Dixon.—CTemp, ATA.

- D. pungens* (H. f. and W.) Par.—UWTemp to LWSup, ATA.
D. robustum (H. f. and W.) Par.—UWTemp to LWSup, ATA.
Distichium capillaceum (Sw.) Bry. eur.—nr. Mt. Hector, c. 1300 m. (reported by L. B. Moore).
Ditrichum elongatum (H. f. and W.) Mitt.—6960, Mt. Marima, c. 400 m.
D. flexifolium (Hook.) Hampe.—UWTemp, CTemp, NTA, WTA.
Holomitrium perichaetiale (Hook.) Brid.—9176, Ohau R., c. 200 m.

Dicnemonaceae.

- Mesotus celatus* Mitt.—7113, Mt. Mitre, c. 1200 m.
Dicnemon calycinum (Hook.) Schwaegr.—WTemp, ATA.
D. semicryptum C.M.—6897, Te Matawai Hut, c. 900 m.; 7627, 7635, Field Hut, c. 850 m.

Leucobryaceae.

- Leucobryum candidum* (Brid.) H. f. and W.—WTemp, LCTemp, ATA.

Pottiaceae.

- Calypotopogon mnioides* (Schwaegr.) Broth.—7185, Wairongomai R., c. 200 m.
Tortella calycina (Schwaegr.) Dixon.—9134, Akatarawa Saddle, c. 400 m.
Tortula princeps De Nots.—9145, Ohau-iti R., c. 300 m.
T. rubra Mitt.—nr. Mt. Hector, c. 1400 m. (reported by L. B. Moore).
Tridontium tasmanicum Hook.—WTemp, ATA; Mt. Hector, c. 1300 m.
Weisia viridula Hedw.—7051, Manawatu Gorge.

Orthotrichaceae.

- Macromitrium eucalyptorum* Hampe and C. M.—7201, 7220, Wairongomai R., c. 200 m.
M. gracile (Hook.) Schwaegr.—LWTemp, ATA.
M. longpipes (Hook.) Schwaegr.—WTemp, LCTemp, ATA.
M. prorepens (Hook.) Schwaegr.—7207, Ohau-iti R., c. 300 m.; 9152, Ruamahanga R., c. 320 m.
M. Pusillum Mitt.—7195, Wairongomai R., c. 200 m.
M. retusum H. f. and W.—UWTemp, NTA.
M. Weymouthii Broth.—9154, Ruamahanga R., c. 320 m.
Orthotrichum tasmanicum H. f. and W.—6666, Te Matawai, c. 900 m.
Schlotheimia Brownii Brid.—7276, Ohau-iti R., c. 300 m.
Ulota breviseta Malta.—9155, Ruamahanga R., c. 320 m.
U. laticiliata Malta.—7609, Field Hut, c. 850 m.
Zygodon intermedius B. and S.—6912, 6977, Mt. Marima, c. 400 m.

Splachnaceae.

- Tayloria purpurescens* (H. f. and W.) Broth.—7264, nr. Field Hut, c. 950 m.

Bryaceae.

- Bryum blandum* H. f. and W.—7422, etc., LWSubp.
B. chrysoneuron C. M.—UWTemp, LCTemp, ATA.
B. truncorum Brid.—WTemp, LCTemp, ATA.
Webera nutans Hedw.—7398, 7626, nr. Field Hut, c. 950 m.
W. tenuifolia (H. f. and W.) Jaeg.—17147, Manawatu Gorge,
 c. 150 m.

Leptostomaceae.

- Leptostomum inclinans* R. Br.—UWTemp, CTemp, ETA, STA.
L. macrocarpum (Hedw.) R. Br.—6915, Mt. Marima, c. 200 m.;
 Wairongomai R., c. 50 m.

Mniaceae.

- Mnium rostratum* Schwaegr.—WTemp, STA.

Rhizogoniaceae.

- Cryptopodium bartramiioides* (Hook.) Brid.—Temp, NTA, WTA.
Rhizogonium bifarium (Hook.) Schimp.—WTemp, LCTemp,
 -ATA.
R. distichum (Sw.) Brid.—WTemp, LCTemp, ATA.
R. mnioides (Hook.) Schimp.—9125, Ruamahanga R., c. 320 m.;
 Akatarawa Saddle, c. 400 m.

Bartramiaceae.

- Bartramia papillata* H. f. and W.—LWSubp.
Breutelia elongata (H. f. and W.) Mitt.—LWSubp.
B. pendula (Hook.) Mitt.—UCTemp, LWSubp, ATA.
Conostomum australe Sw.—7427, Mt. Hector; Mt. Mitre; c. 1500
 m.
C. pusillum H. f. and W.—LWSubp.
Philonotis australis (Mitt.) Jaeg.—Manawatu Gorge; Akatarawa
 Saddle; 7646, nr. Mt. Hector, c. 1300 m.
P. tenuis (Tayl.) Jaeg.—Manawatu G., Akatarawa Saddle; 7436,
 Mt. Hector, c. 1300 m.

Hypnodendraceae.

- Hypnodendron arcuatum* (Hedw.) Mitt.—WTemp, LCTemp,
 WTA, STA.
Mniodendron comatum (C. M.) Lind.—7257, Ohau-iti R., c. 300
 m.; 7126, Orongorongo R., c. 600 m.
Sciadocladus Menziesii (Hook.) Lindb.—UWTemp, LCTemp,
 ATA.

Rhacopilaceae.

- Rhacopilum strumiferum* C.M.—LWTemp, ATA.

Cryphaeaceae.

- Cryphaea dilatata* H. f. and W.—6959, Mt. Marima, c. 200 m.;
 Akatarawa Saddle, c. 300 m.
C. tasmanica Mitt.—7289, Ohau-iti R., c. 400 m.; 9129, Ruama-
 hanga R., c. 400 m.

Hedwigiaceae.

- Rhacocarpus australis* (Hampe.) Par.—UCTemp, LWSubp, ATA.

Ptychomniaceae.

Cladomnion ericoides (Hook.) H. f. and W.—WTemp, LCTemp, ATA.

Glypothercium alare Dix and Sainsb.—7526, nr. Field Hut, c. 850 m.

Ptychomnion aciculare (Brid.) Mitt.—Temp, LWSup, ATA.

Gyrtopodaceae.

Cyrtopus setosus (Hedw.) Hook. f.—UWTemp, ATA.

Pterobryaceae.

Trachyloma planifolium (Hedw.) Brid.—UWTemp, ATA.

Meteoriaceae.

Papillaria amblyacis (C. M.) Jaeg.—7272, Ohau-iti R., c. 300 m.

P. crocea (Hampe.) Jaeg.—WTemp, NTA, STA.

P. filipendula (H. f. and W.) Jaeg.—7237, Wairongomai R., c. 100 m.

P. flavo-limbata (C. M. and Hampe.) Jaeg.—WTemp, LCTemp, ATA.

P. flexicaulis (Tayl.) Jaeg.—9230, Tokomaru R., c. 100 m.; LWTemp, STA.

Weymouthia cochlearifolia (Schwaegr.) Dix.—LCTemp, ATA.

W.c. Billardieri (Hampe.) Dixon.—UWTemp, LCTemp, ATA.

W.c.f. flagellifera.—WTemp, ATA.

W. mollis (Hedw.) Broth.—WTemp, LCTemp, ATA.

Phyllogoniaceae.

Orthorrhynchium elegans (H. f. and W.) Reichdt.—7106, Ohau-iti R., c. 300 m.

Neckeraceae.

Homalia falcifolia (H. f. and W.) H. f. and W.—WTemp, NTA.

H. pulchella H. f. and W.—WTemp, NTA.

Nekera hymenodonta C.M.—7242, Wairongomai R., c. 200 m.

Porotrichum oblongifolium (H. f. and W.) Broth.—6878, Tiritea R., c. 400 m.

Thamnium latifolium (Bry. jav.) Par.—7454, 7462, Field Hut, c. 850 m.

T. pandum (H. f. and W.) Jaeg.—6898, Tiritea R., c. 150 m.; 7577, nr. Field Hut, c. 850 m.

Echinodiaceae.

Echinodium hispidum (H. f. and W.) Jaeg.—WTemp, ATA.

Lembophyllaceae.

Acrocladium auriculatum (Mont.) Mitt.—Temp, ATA.

Camptochaete angustata (Mitt.) Jaeg.—6899, Tiritea R., c. 150 m.; 7234, Wairongomai R., c. 150 m.

C. arbuscula (Hook.) Jaeg.—UWTemp, LCTemp, NTA; 7460, 7532, nr. Field Hut, c. 850 m.

C.a. deflexa (Wils.) Dix.—7258, Ohau-iti R., c. 300 m.

C. gracilis (H. f. and W.) Par.—WTemp, ATA; nr. Mt. Hector, c. 1400 m.

C. ramulosa (Mitt.) Jaeg.—7189, 7233, Wairongomai R., c. 50 m.; 9123, Ruamahanga R., c. 320 m.

Lembophyllum clandestinum (H. f. and W.) Lindb.—WTemp, LCTemp, ATA.

Hookeriaceae.

- Bellia nervosa* (H. f. and W.) Broth.—6976, Mt. Marima, c. 200 m.; 7548, etc., nr. Field Hut, c. 850 m.
Daltonia novae-zelandiae Mitt.—9155d, Ruamahanga R., c. 320 m.
Distichophyllum amblyophyllum (H. f. and W.) Mitt.—LCTemp, ATA.
D. microcarpum (Hedw.) Mitt.—6822, Tiritea R., c. 400 m.
D. puchellum (H. f. and W.) Mitt.—WTemp, LCTemp, NTA, WTA.
D. rotundifolium (H. f. and W.) Broth.—6929, 6973, Mt. Marima, c. 200 m.; 7543, nr. Field Hut, c. 850 m.
Eriopus cristatus (Hedw.) Jaeg.—6867, Tiritea R., c. 400 m.; 7553, 7557, nr. Field Hut, c. 850 m.
E. flexicollis (Mitt.) Jaeg.—7593, nr. Field Hut, c. 850 m.
Pterygophyllum dentatum (H. f. and W.) Mitt.—WTemp, ATA.
P.d. robustum (H. f. and W.) Dixon.—WTemp, ATA.
P. quadrifarum (Hook.) Brid.—UWTemp, LCTemp, ATA.

Hypopterygiaceae.

- Catharomnion ciliatum* (Hedw.) H. f. and W.—LWTemp, NTA.
Cyathophorum bulbosum (Hedw.) C. M.—WTemp, LCTemp, ATA.
Hypopterygium concinnum (Hook.) Brid.—WTemp, ATA.
H. filiculaeforme (Hedw.) Brid.—WTemp, NTA.
H. novae-seelandiae C. M.—UWTemp, LCTemp, ATA.
H. setigerum (P. Beauv.) H. f. and W.—WTemp, ATA.

Thuidiaceae.

- Thuidium furfurosum* (H. f. and W.) Jaeg.—WTemp, ATA.
T. laeviusculum (Mitt.) Jaeg.—WTemp, ATA.

Amblystegiaceae.

- Campylium relaxum* (H. f. and W.) Broth.—7642, nr. Mt. Hector, c. 1300 m.
Drepanocladus fluitans (Hedw.) Warnst.—LWSubp.

Brachytheciaceae.

- Brachythecium paradoxum* (H. f. and W.) Jaeg.—7419, Mt. Hector, c. 1400 m.
P. plumosum (Hedw.) Bry. eur.—WTemp, ATA.
B. rutabulum (Hedw.) Bry. eur.—7249, Wairongomai R., c. 100 m.
Eriodon cylindritheca (Dixon).—9137, Akatarawa Saddle, c. 400 m.
Eurhynchium asperipes (Mitt.) Dixon.—7563, etc., nr. Field Hut, c. 850 m.
E. muriculatum (H. f. and W.) Jaeg.—6972, Mt. Marima, c. 400 m.; 6945, Mt. Mitre, c. 750 m.

ANALYSIS OF THE DISTRIBUTION OF MUSC.

		Total (38 families)																																									
Belts	Areas	Sphagnaceae	Andreaeaceae	Calomniaceae	Dawsoniaceae	Polytrichaceae	Elasmodontaceae	Grimmiaceae	Dicranaceae	Dicranomomaceae	Leucobryaceae	Portiaceae	Orthotrichaceae	Spilachnaceae	Bryaceae	Leptostomaceae	Mniaceae	Rhizogoniaceae	Batrachaceae	Hypnoidendraceae	Rhacopilaceae	Cyphaceae	Hedwigiaceae	Psychomniaceae	Cyrtopodaceae	Pterobryaceae	Metzoriaceae	Phyllogoniaceae	Neckeriaceae	Rehmodiaceae	Lembophyllaceae	Hookeriaceae	Hypopterygiaceae	Thuidiaceae	Amblystegiaceae	Brachytheciaceae	Sematophyllaceae	Hypnaceae	Hylcomniaceae				
No. of genera		1	1	1	1	6	1	2	10	2	1	5	5	1	2	1	1	2	4	3	1	1	1	1	3	1	1	1	2	1	4	1	3	5	3	1	2	3	2	1	1		
Warm Subpolar		1	4	—	1	—	4	8	—	2	—	—	—	1	—	—	—	7	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	2	1	—	1	1		
Cold Temperature		2	1	—	—	6	5	2	12	1	1	—	2	1	3	—	—	3	1	2	—	—	1	3	—	—	—	—	4	—	2	—	8	7	2	—	—	1	2	1	—	—	
WTA ..		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
NTA ..		1	—	—	3	1	2	11	—	1	—	1	—	2	—	2	—	3	1	1	—	—	1	2	—	—	—	—	4	—	—	2	3	2	—	—	—	—	2	1	—	—	
ETA ..		2	—	—	3	1	2	8	1	1	—	1	—	1	—	2	1	2	1	1	—	—	1	2	—	—	—	—	4	—	—	2	2	2	—	—	—	1	2	1	—	—	
STA ..		2	—	—	3	1	2	8	—	1	—	1	—	1	—	2	1	2	1	2	—	—	1	2	—	—	—	—	4	—	—	2	2	2	—	—	—	2	1	—	—		
Total ..		4	1	—	6	5	2	13	2	1	—	3	1	3	1	3	1	3	1	2	—	—	1	3	—	—	—	4	—	2	—	3	7	2	—	—	2	2	1	—	—		
Warm Temperature		—	—	—	1	2	2	1	10	1	1	1	2	—	2	—	—	3	—	2	1	—	—	2	1	1	1	4	—	—	1	3	4	4	2	—	1	2	1	—	—		
WTA ..		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
NTA ..		—	—	1	1	3	0	1	13	1	1	3	5	—	3	1	—	3	2	2	1	2	—	2	1	1	7	1	4	1	6	8	6	2	—	2	2	1	—	—			
ETA ..		—	—	—	1	3	2	1	8	1	1	1	5	—	2	1	—	3	—	1	1	—	2	1	1	4	—	—	1	4	4	4	2	—	1	4	4	2	—	1	3	1	—
STA ..		—	—	—	1	2	2	2	8	1	1	3	5	—	2	2	1	3	2	3	1	1	—	2	1	1	7	—	1	1	5	3	4	2	—	3	4	1	—	—			
Total ..		—	—	1	1	4	6	2	13	1	1	5	10	—	3	2	1	4	2	3	1	2	—	2	1	1	8	1	5	1	7	9	6	2	—	4	4	1	—	—			
Grand Total		5	4	1	1	10	8	4	22	3	1	6	12	1	5	2	1	4	7	3	1	2	1	3	1	1	1	9	1	6	1	7	11	6	2	2	6	4	2	1	167		

Sematophyllaceae.

Acanthocladium extenuatum (Brid.) Mitt.—WTemp, LCTemp, ATA.

Sematophyllum amoenum (Hedw.) Dixon.—UWTemp, LCTemp, ATA.

S. contiguum (H. f. and W.) Dixon.—7230, Wairongomai R., c. 100 m.

S. tenuirostre (Hook.) Dixon.—7156, Orongorongo R., c. 600 m.; 7280, Akatarawa Saddle, c. 400 m.; 9124, Ruamahanga R., c. 320 m.

Hypnaceae.

Hypnum chrysogaster C. M.—CTemp, ATA.

H. cupressiforme Hedw.—WTemp, ATA; 7444, Mt. Hector, c. 1400 m.

Hylocomniaceae.

Hylocomnium splendens (Hedw.) Bry. eur.—7430, Mt. Hector, c. 1400 m.

BRYOPHYTA—HEPATICAE.

V. D. Zorov and E. A. Hodgeson.

As in the cases of mosses, collections of liverworts were made in representative localities. Judging from the fact that a large number of species were collected only once or twice, it would appear that the present list must be by no means exhaustive. It must also be borne in mind that the present knowledge of the New Zealand hepatics is very imperfect, so that errors in identification are likely to have crept in. To facilitate future work, numbers are given of all specimens except of those species well represented in the collection, which is deposited in the herbarium of the Plant Research Bureau, Palmerston North.

The families in the list are arranged according to the system adopted by Verdoorn (1932).

Epigonanthaceae.

Acrobolbus lophocoleoides Mitt.—9209, Akatarawa Sad., c. 400 m.

Anastrophyllum schismoides (Mont.).—6642, 6663, Te Matawai, c. 900 m.

Chandonanthus squarrosus (Hook.).—7174, Orongorongo R., c. 600 m.

Chiloscyphus aculeatus Mitt.—9218, Akatarawa Saddle, c. 400 m.

C. allodonta (H. f. and T.) comb. nov.—9251, Ruamahanga R.; 9175, Ohau-iti R.; 9276, Akatarawa Saddle, all c. 300 m.

C. bidentatus St.—6664, Te Matawai, c. 900 m.

C. Billardiieri Nees.—6660, Te Matawai, c. 900 m.

C. ciliatus St.—7677, nr. Kime Hut, c. 1260 m.; 7170, Orongorongo R., c. 600 m.; 6660, Te Matawai, c. 900 m.

C. coalitus Nees.—7281, Ohau-iti R., c. 300 m.

C. Colensoi Mitt.—7295, Ohau-iti R., c. 300 m.

C. cuneistepulus?—7483, 7534, 7545, 9180, 9174, UWTemp, ATA.

- C. decipiens* Gottsche.—6672, Te Matawai, c. 900 m., 9232, Mt. Pukematawai, c. 1200 m.
- C. echinellus* Mitt.—7490, nr. Field Hut, c. 850 m.
- C. fissistipus* H. f. and T.—6983, Mt. Tarakamuku, c. 500 m.; 9215, Akatarawa Saddle, c. 400 m.
- C. involucratu* Col.—9173, Ohau-iti R., c. 300 m.
- C. odoratus* Mitt.—7281, Ohau-iti R., c. 300 m.
- C.*—7414, 7403, 7678, 7689, Mt. Hector, c. 1500 m.
- C.*—9220, Akatarawa Saddle, c. 400 m.
- C.*—9209, Akatarawa Saddle, c. 400 m.
- C. physanthus* Mitt.—4775, Tiritea R., c. 100 m.
- C.*—7681, nr. Kime Hut, c. 1350 m.
- C.*—7181, Wairongomai R., c. 50 m.
- Cuspidatula monodon* (H. f. and T.) St.—6932, Mt. Marima, c. 400 m.; 7305, Ohau-iti R., c. 300 m.; 7465, nr. Field Hut, c. 850 m.
- Geocalyx novae-zealandiae* Herz.—7285, Ohau-iti R., c. 300 m.
- Haplozia rotata* H. f. and T.—4759, Tiritea R., c. 100 m.
- H.*—7498, Mt. Hector, c. 1400 m.
- Jamesoniella colorata* (Lehm.)?—7661, nr. Kime Hut, c. 1350 m.
- J. Kirkii* St.—9245, Ruamahanga V., c. 120 m.
- J. occlusa* (Tayl.).—7410, Mt. Hector, c. 1400 m.
- J. Sonderi.*—7418, Mt. Hector, c. 1400 m.; 9256, Ruamahanga R., c. 320 m.
- J.*—7495, Mt. Hector, c. 1400 m.
- Lophocolea crassiretis* Herz.—6644, Te Matawai, c. 900 m.
- L. decurva* Mitt.—7095, 7096, Ohau-iti R., c. 300 m.; 7168, Orongorongo R., c. 600 m.
- L. erectifolia* St.—7285, Ohau-iti R., c. 300 m.
- L. heterophylloides* Nees.—WTemp, NTA; 7226, Wairongomai R., c. 50 m.
- L. lenta* H. f. and T.—6940, Mt. Marima, c. 400 m.
- L. muricata* Nees.—6668, 6686, Te Matawai, c. 900 m.
- L. planiuscula* H. f. and T.—4836, Mt. Bannister, c. 1450 m.
- L. unduliflora* Gottsche.—9170, Ruamahanga V., c. 320 m.
- L. Zotovii* Herz.—7499, Mt. Hector, c. 1400 m.
- L.*—7685, nr. Kime Hut, c. 1350 m.
- L.*—6699, Manawatu Gorge, c. 100 m.
- Plagiochila annotina* Lindb.—6814, Ohau R., c. 250 m.; 6658, Te Matawai, c. 900 m.
- P. arbuscula* L. et L.—WTemp, NTA, STA.
- P. Beckettiana* St.—7640, nr. Kime Hut, c. 1350 m.
- P. conjugata* Lindb.—7308, Ohau-iti R., c. 300 m.; 9221, Akatarawa Saddle, c. 400 m.
- P. deltoidea* Lindb.—6825, Tiritea R., c. 300 m.
- P. fasciculata* Lindb.—WTemp, NTA; 9279, Akatarawa Saddle, c. 400 m.
- P. fruticella* H. f. and T.—9211, 9208, Akatarawa Saddle, c. 400 m.; 7168, Orongorongo R., c. 600 m.; 7280, Ohau-iti R., c. 300 m.
- P. gigantea* Lindb.—WTemp, NTA; 9213, Akatarawa Saddle.

- P. Helmsii* St.?—6690, Te Matawai, c. 900 m.; 9241, Ruamahanga V., c. 320 m.; 7176, Orongorongo R., c. 600 m.
P. Howeana St.—6658, Te Matawai, c. 900 m.; 7456, nr. Field Hut, c. 850 m.
P. Kirkii St.—6717, Mt. Arawaru, c. 600 m.
P. Lyallii Mitt.—WTemp, NTA, STA; 7664, nr. Kime Hut, c. 1350 m.
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P. multidentata St.—4805, Manawatu Gorge, c. 150 m.
P. ramosissima Lindb.—6653, Te Matawai, c. 900 m.
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P.—9255, 9250, Ruamahanga R., c. 320 m.; 7663, nr. Kime Hut, c. 1350 m.
Saccogyna australis Mitt.—9219, Akatarawa Saddle, c. 400 m.; 9172, Ohau-iti R.; 1714, Ruamahanga R., c. 320 m.
Tylinanthus flaccidus Bergg.?—7133, Orongorongo R., c. 600 m.
T. saccatus Mitt.—UWTemp, LCTemp, ATA.
T.—9263, Ruamahanga R., c. 320 m.

Schistochilaceae.

- Balantiopsis converiusculis* Berggr.—9207, Akatarawa Saddle, c. 400 m.
B. diplophyllum (Mitt.).—6893, Tiritea R., c. 300 m.; 7103, Ohau-iti R., c. 300 m.; 7487, nr. Field Hut, c. 850 m.
Schistochila appendiculata (Nees).—WTemp, NTA.
S. Balfouriana (H. f. and T.).—9182, Akatarawa Saddle, c. 400 m.
S. ciliata Mitt.—6674, Te Matawai, c. 900 m.; 9235, Ruamahanga R., c. 320 m.
S. glaucescens Nees.—WTemp, NTA, STA.
S. muricata Herz. et Hodg.—7489, nr. Field Hut, c. 850 m.
S. nobilis Nees.—UWTemp, LCTemp, ATA.
S. repleta (H. f. and T.).—7265, 7291, Ohau-iti R., c. 300 m.
S. splachnophylla (H. f. and T.).—7405, nr. Mt. Hector.
S. unguicularis (H. f. and T.).—6970, Mt. Marima, c. 400 m.

Cephalozellaceae.

- Cephalozella exiliflora* (Tayl.)?—6938, Mt. Marima, c. 400 m.

Trigonanthaceae.

- Acromastigum anisostomum* (L. and L.) Evans.—6648, Te Matawai, c. 900 m.
A. Colensoanum (Mitt.) Ev.—7294, Ohau-iti R., c. 300 m.
Bazzania adnexa (L. and L.).—UWTemp, LCTemp, ATA.
B. fissistipa St.—7561, nr. Field Hut, c. 850 m.
B. monilinerve (Nees).—9271, Ruamahanga R., c. 320 m.
B. novae-zealandiae Mitt.—UWTemp, LCTemp, ATA.
B. Tayloriana Mitt.—7084, Ohau R., c. 250 m.; 9217, 9218, Akatarawa Saddle, c. 400 m.
B.—6628, Oriwa Lake-Hollow, c. 900 m.
Cephalozia multicuspidata (H. f. and T.)?—7491, 7492, 7493, Mt. Hector, c. 1450 m.

- Lembidium ventrosum* St.?—7364, 7533, 7606, nr. Field Hut, c. 850 m.
L.—7648, nr. Kime Hut, c. 1350 m.
Lepidozia novae-zelandiae St.—7279, 7297, Ohau-iti R., c. 300 m.
L. capilligera Lindb.—UWTemp, LCTemp, WTA.
L. centipes Tayl.—9252, Ruamahanga R., c. 320 m., 7619, nr. Field Hut, c. 850 m.
L. Lindenbergii Gottsche.—WTemp, NTA, STA.
L. praeinitens L. et L.—UWTemp, LCTemp, ATA.
L. spinosissima.—7081, 7299, Ohau-iti R., c. 300 m., 9298, Akatarawa Saddle, c. 400 m.
L. ulothrix Labg.—6659, Te Matawai, c. 900 m.
L. compacta.—7089, Ohau-iti R., c. 300 m.
L.—6685, Te Matawai, c. 900 m.
L.—6938, Mt. Marima, c. 400 m.
L.—6701, Mt. Arawaru, c. 600 m.
L.—9289, Akatarawa Saddle, c. 400 m.
L.—9265, Akatarawa Saddle, c. 400 m.
L.—7275, Ohau-iti, c. 300 m.
L.—6619, Oriwa Lake-Hollow, c. 900 m.; 9290, Akatarawa Saddle, c. 400 m.; 9268, 9275, Ruamahanga R., c. 320 m.
L. carcarata var. *minor*.—7397, Mt. Dennan, c. 1050 m.; 7415, Mt. Hector, c. 1400 m.
L.—6625, 6629, Oriwa Lake-Hollow, c. 900 m.; 7089, Ohau-iti, c. 300 m.; 9269, Ruamahanga R., c. 320 m.
L.—6685, Te Matawai, c. 900 m.
L.—7404, Mt. Hector, c. 1400 m.
Marsupidium abbreviatum H. f. and T.?—6698, Manawatu Gorge, c. 150 m.
M. Knightii Mitt.—6816, Tiritea R., c. 300 m.; 7597, nr. Field Hut, c. 850 m.
Psiloclada clandestina Mitt.—9263, Ruamahanga R., c. 320 m.
Zoopsis argentea H. f. and T.—6841, Tiritea R., c. 300 m.
Z. foliosa Herz. and Hodg.—9178, 9297, Akatarawa Saddle, c. 400 m.
Z. Leitgebiana C. and P.—7537, nr. Field Hut, c. 850 m.; 6620, Oriwa Lake-Hollow, c. 900 m.
Z. setulosa Leitgeb.?—9299, Akatarawa Saddle, c. 400 m.
Z.—7619, nr. Field Hut, c. 850 m.

Ptilidiaceae.

- Blepharostoma palmatum* (Labg.).—7496, 7497, Mt. Hector, c. 1400 m.
Herberta alpina St.—6643, 6667, Te Matawai, c. 900 m.
Isotachis sp. (cf. *I. flavicans* of Chile).—7407, Mt. Hector, c. 1400 m.
I. humectata (Tayl.) f. *calcarata*.—7401, 7409, etc., Mt. Hector, c. 1400 m.
I. Lyallii Mitt.—UWTemp, LCTemp, WTA.
I. montana Col.—LCTemp, WTA.
I. montana f. *subdentata*.—7649, nr. Kime Hut, c. 1350 m.
Lepidolea scolopendra Nees.—UWTemp, LCTemp, ATA.
Lepidolea clavigera Gottsche.—WTemp, NTA, STA.

- L. magellanica* (Gottsche).—9231, Pukematawai, c. 1450 m.
L. Menziesii (Gottsche).—4815, Ohau R., c. 250 m.
L. paepebrifolia (Gottsche).—9265, Ruamahanga V., c. 320 m.
L. Taylori (Gottsche).—WTemp, NTA; 9281, Akatarawa Saddle, 400 m.
Mastigophora flagellifera Nees.—WTemp, NTA, STA.
Trichocolea australis St.—UWTemp, LCTemp, ATA.
T. australis f.—7657, 7659, nr. Kime Hut, c. 1350 m.
T. australis f.—9274, Ruamahanga V., c. 320 m.
T. australis f.—6879, Tiritea R., c. 300 m.
T. lanata Nees.—6875, Tiritea R., c. 150 m.; 7263, Ohau-iti R., c. 300 m.; Ruamahanga R.

Goebeliellaceae.

- Goebeliella cornigera* (Mitt.) St.—CTemp, LWSup, ATA.

Radulaceae.

- Radula buccinifera* H. f. and T.—6889, Tiritea R., c. 300 m.; 6979, Mt. Marima, c. 400 m.
R. grandis St.—6889, Tiritea R., c. 300 m.; 9118, Akatarawa Saddle, c. 400 m.
R. levieri St.—4811, 4773, Tiritea R., c. 200 m.; nr. Field Hut, c. 850 m.; 9169, Akatarawa Saddle, c. 400 m.
R. uvifera H. f. and T.?—7228. Wairongomai R., c. 50 m.

Porrellaceae.

- Madotheca Stangeri* Gottsche.—WTemp, LCTemp, ATA.

Lejeuniaceae.

- Archilejeunia olivacea* H. f. and T.—7307, Ohau-iti R., c. 300 m.
Eulejeunia Kirkii St.—7527, nr. Field Hut, c. 850 m.
E. nudipes H. f. and T.—17099, Tiritea R., c. 300 m.
Harpalejeunia Colensoi St.—9189, Akatarawa Saddle, c. 400 m.
 "Lejeunia."—6722, Mt. Arawaru, c. 600 m.
 "L."—7406, Mt. Hector, c. 1400 m.
Physocolea laevigata (Mitt.).—6812, Tiritea R., c. 300 m.; 6650, Te Matawai, c. 900 m.
Strepsilejeunia Curnowii St.?—6979, Mt. Marima, c. 400 m.
Thysananthus anguiformis (H. f. and T.)—7303, 7097, Ohau-iti R., c. 300 m.; 9179, 9300, Akatarawa Saddle, c. 400 m.

Frullaniaceae.

- Frullania deplanata* Mitt.—7453, nr. Field Hut, c. 850 m.
F. pycnantha H. f. and T.—7142, 7178, 7180, Orongorongo R., c. 400 m.
F. rostellata Mitt.—7042, Ohau-iti R., c. 300 m.
F. spinifera H. f. and T.—7223, 7235, Wairongomai R., c. 50 m.; 7041, 7025, Ohau-iti R., c. 300 m.
F.—7236, 7240, Wairongomai R., c. 50 m.
F.—6974, Mt. Marima, c. 400 m.

Treubiaceae.

- Treubia insignis* Goebel.—7284, Ohau-iti, c. 300 m.

Haplolaenaceae.

- Calycularia Cockaynei* (Goeb.) St.—7674, Kime Hut, c. 1380 m.

Monocleaceae.

- Monoclea Forsteri* Hook.—WTemp, ATA.

Dilaenaceae.

- Pallavicinia connivens* (Col.) St.—7607, nr. Field Hut, c. 850 m.
P. xiphioides (Tayl.)—7565, nr. Field Hut, c. 800 m.
P. sp. nov.—9197, Akatarawa Saddle, c. 400 m.
Symphyogyna hymenophyllum Mont.—WTemp, CTemp, ATA.
S. obovata Tayl?—9191, Akatarawa Saddle, c. 400 m.
S. subsimplex.—4767, Tiritea R., c. 150 m.

Metzgeriaceae.

- Hymenophyllum flabellatum* (Mont.) St.—UWTemp, CTemp, ATA.
H. leptodon (H. f. and T.) St.—WTemp, LCTemp, ATA.
H. phyllanthus (Hook.) St.—UWTemp, LCTemp, ATA.
Metzgeria Colensoi St.?—6706, Mt. Arawaru, c. 600 m.
M. decipiens (Massal) Schiff. and Gottsche.—6926, Mt. Marima, c. 400 m.
M. hamata Lindb.—6924, 6980, Mt. Marima, c. 400 m.; 7479, 7555, nr. Field Hut, c. 850 m.; 7680, 7684, nr. Kime Hut, c. 1350 m.
M. nitida Mitt.—7184, Wairongomai R., c. 50 m.
M.—7688, nr. Kime Hut, c. 1350 m.
M.—7481, nr. Kime Hut, c. 1350 m.
M.—7225, Wairongomai R., c. 50 m.

Aneuraceae.

- Riccardia alterniloba* (H. f. and T.)—WTemp, NTA, STA.
R. bipinnatifida Col.—6984, nr. Manawatu G., c. 200 m.
R. eriocaula (Hook.)—UWTemp, LCTemp, ATA.
R. marginata (Col.)?—6963, Mt. Marima, c. 400 m.
R. micropinna (St.)—9204, 9205, Akatarawa Saddle, c. 400 m.
R. perpusilla (Col.)?—7477, nr. Field Hut, c. 850 m.
R. Polymorpha (Col.)?—Temp, ATA; 7413, Mt. Hector c. 1400 m.
R.—6662, Te Matawai, c. 900 m.
R.—7616, nr. Field Hut, c. 850 m.
R.—6784, nr. Manawatu G., c. 200 m.; 7402, 7417, Mt. Hector, c. 1400 m.
R.—7411, 7416, Mt. Hector, c. 1400 m.
R.—9234, Pukematawai, c. 1450 m.
R.—7474, nr. Field Hut, c. 850 m.
R.—7365, nr. Field Hut, c. 850 m.
R.—6645, Te Matawai, c. 900 m.
R.—7484, nr. Field Hut, c. 850 m.
R.—9233, Pukematawai, c. 1450 m.
R.—6665, Te Matawai, c. 900 m.

Marchantiaceae.

- Lunaria cruciata*.—4845, 7053, Manawatu G., c. 100 m.
Marchantia foliacea Mitt.—WTemp, LCTemp, ATA.
M. tabularis Nees.—WTemp, NTA; 7587, nr. Field Hut, c. 850 m.
M. sp. nov.—7485, nr. Field Hut, c. 850 m.

Operculatae.

- Asterella tenera* (Mitt.)—7282, Ohau-iti R., c. 300 m.

Anthocerotaceae.

- Anthoceros coriaceus*?—17145, Manawatu G., 100 m.

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A Systematic Classification of *Pseudococcus* and Some Related Genera—Part I.

By G. BRITTIN.

[Read before the Auckland Institute, September 21, 1938; received by the Editor, August 1, 1938; issued separately, December, 1938.]

THE literature dealing with the systematic classification of the Coccidae, with few exceptions, is extremely unsatisfactory; particularly is this so in New Zealand, where practically nothing has been done to remedy it. G. F. Ferris (1918), when reporting on some mealy bugs found in California, made the following statement, which is as true to-day as it was then:—" . . . Of the nearly 100 mealy bugs thus far described from North America, including some 35 from California, not more than three or four are recognisable at all on the basis of the published descriptions if taken apart from their typical host and type locality." This is a challenging statement, and calls for consideration by all students of the group, who must in the future do their best to remedy such a defect. Several have already attempted to solve it with but partial success. Berlese (1893) has described some of the structures that could be made use of in identification, and Marchal (1908) seems to have been the first to make use of them. Smith (1911) investigated the value of characters ordinarily used, and later (1913) discussed the possible value of others. In spite of this, however, very little progress appears to have been made.

It was in the early days of my studies that the difficulty of identifying already-named species made itself so apparent, and but for the courtesy of the Government Entomologist at that time, in allowing me to examine the type slides of the Maskell collection, and also for the assistance rendered by Mr E. E. Green, who had received specimens from Mr Maskell, I would have been forced to give up. Thus at the outset I decided that as soon as my collection approached anything near a reasonable number, I would endeavour to take each genus separately and try to bring order out of chaos. The work, of course, has been very slow, and was made more so by the large number of new species discovered, and still being discovered, and also by the fact that many of my earlier preparations were found to be unsatisfactory and had to be re-mounted; again, the loss of specimens when transferring from one place to another added to my difficulties. Further trouble was also experienced through not being able to find workable descriptions of the different genera concerned, since every author appeared to have his own opinion as to what should be considered generic characters. However, thanks to scientific friends, the difficulty has been overcome as far as the group of genera here mentioned is concerned, and I trust that this will be only the first of a series of papers containing descriptions of all new species, and re-descriptions of all species

already named, which occur in New Zealand. Myers (1922), in his reference list of the N.Z. Coccidae, refers to 22 named species of the Pseudococcinae, of which one species, *P. comstocki* Kuwana, was wrongly identified, and the type slide of another, *P. arecae* Mask., contains only a small portion of the insect, and consequently is quite useless for the purpose of identification. To Myers's list it is now necessary to add another 30 distinct species which belong to the following three genera: *Trionymus* 20; *Pseudococcus* 9; *Ripersiella* 1; making a grand total of at least 50 distinct species of Pseudococcinae in New Zealand.

MORPHOLOGICAL CHARACTERS.

Before dealing with the taxonomic value of the morphological characters, it will not be amiss to explain how classification was carried out in the past. Costa was supposed to have erected the first genus, *Dactylopius*, on the basis of an eight-jointed antenna. As collections progressed, specimens were found with both fewer and more joints than eight, though otherwise apparently related. Westwood separated those with nine-jointed antennae under the name of *Pseudococcus*, and Signoret those with six joints under the name of *Ripersia*. Later, Signoret again separated another portion on the basis of greater body length, to form the genus *Westwoodia*, which genus, after much alteration, now appears under the name of *Trionymus* Berg. Due to the investigations of Marie E. Fernald into the literature of the Coccidae, several changes in nomenclature had to be made, as the name *Dactylopius* had to be transferred to quite a distinct subfamily, and *Pseudococcus*, next in priority, was substituted for it, while the name *Phenacoccus* was substituted for that of *Pseudococcus*. It will be seen therefore, that the number of antennal joints was the main basis for the separation of the genera, and as it has since been shown that this is probably the most variable organ of the body, it is little wonder that so much confusion resulted.

Although it was only recently that I became aware of the lines along which other students of the group were working, I had long been studying the problem, and had drawn up a list of all characters likely to be of taxonomic value, and had applied them to my own collection. The result as far as the New Zealand species of these genera are concerned appears to be quite satisfactory.

Adult female.

Antenna.—Very little reliance should be placed on the antennal characters, owing to their great variability. They have their uses in dividing a genus, however, into two or more groups according to the number of joints, but a large allowance must be made for error, as in a number of species it will be found to vary from six to seven or seven to eight joints. It is also useful to know which is the shortest joint usually found in a species, as this character appears to be fairly constant.

Legs.—Considerable attention was paid to the legs to see if they possessed any characters of taxonomic value. The most reliable constant characters found were the groups of minute pores which may be observed on one or more joints of the hind legs of different species. These proved very useful in further separating the groups of species into still smaller groups, thus aiding identification. It was also useful to make a comparison of the length of the tibia with the tarsus, as this character, though not so constant, has some value. Any denticle on the claw should be noted, as all species with dorsal ostioles found to possess such a denticle will probably belong to the genus *Phenacoccus* irrespective of the number of joints in the antenna.

Mouth parts.—The only character of taxonomic value found was a comparison of the length with the breadth of the so-called mentum, or beak. I have never found this to vary in any species, or variety of a species.

Dorsal Ostioles.—These are really of group importance, and apply to the mealy bugs only. They are never found in the *Eriococcinae* groups. There are usually two pairs of these present, one pair being on the frons, and another pair about the third segment of the abdomen.

Cerarii.—A typical cerarius consists of a pair or more of spines set close together near the margin of the body, and usually accompanied by a more or less closely set group of triangular pores, and sometimes by two or more accessory setae. They are undoubtedly of great importance in the identification of the species, and may also be used in the separation of the genera. One of the weak points of the cerarii is, that though fairly constant as regards the species, they have a way of gradually fading out that makes it sometimes hard to decide where they end, consequently, unless a hard and fast rule is laid down as to what constitutes a cerarius, no two students are likely to agree as to how many a certain species may have. A good instance of this is to be found in the species *P. aurilanatus* Mask., which, according to Ferris (1918), possesses five or six pairs of cerarii. According to my way of thinking there is only a single pair of cerarii, and each cerarius contains two spines, a few grouped triangular pores, and two or three accessory setae. Ferris, in his description of the species, states as follows:—" . . . cerarii present on the last five or six abdominal segments only, each with two cerarian spines, those in the anteriormost are so small and so widely separated as to be scarcely recognisable . . . remaining cerarii with neither grouped pores nor auxiliary setae." There is very little doubt, however, that if a hard and fast rule is laid down as to what shall constitute a cerarius, this difficulty can be overcome, in which case the following diagnosis of a cerarius may probably meet with some approval: A cerarius to consist of one or more spines surrounded by a definite cluster of small triangular pores, with or without accessory setae; in the absence of definitely clustered pores, then a cerarius to consist of two closely-contiguous spines,

easily recognisable by their shape or size from other derm spines or setae, and situated in the proper position for a cerarius.

Anal lobes.—Owing to the anal lobes being in an undeveloped state, they are very little use for taxonomic purposes. In some species there may be a chitinous area on the dorsal or ventral surface of the rudimentary lobes that is worth recording, but otherwise they appear to be of no value.

Derm pores.—These are usually of two types: small triangular, and large disc. The former are similar to those found in the cerarii, have a trilocular centre, and are generally evenly spaced over the dorsal surface of the body, though they may also be found on the ventral surface. The large disc pores are of the multilocular type, and are usually in transverse segmental bands on the ventral surface of the abdomen only; in some species, however, they may be found on the thoracic portion of the body, and also on the dorsum. As regards the taxonomic value of the derm pores, very little use can be made of the triangular pores except to note their relative numbers, as there is no doubt that they are more plentiful in some species than in others, therefore this fact should be noted. The large multilocular disc pores, on the other hand, are certainly of value, there being usually three to five more or less irregular transverse bands on the abdomen, and in one species, *T. obtectus* Mask., in definite single rows. It will be noted that in some species the ends of these bands reach the margin of the body when spread out flat on the slide, while in other species they do not reach more than half way to the margin. This fact is worth noting, as well as the number of the bands—not always an easy matter to observe. The arrangement of these bands appears to be very constant. There is yet one other type of pore found in several of the New Zealand species that may probably necessitate the erection of a new genus. It is of the small circular or roughly triangular, multilocular type, and replaces the triangular trilocular type in at least four species, three of which are subterranean in habits. This type of pore may or may not be accompanied by large disc pores, and apart from their generic value, are likely to be of little use.

Tubular ducts.—There are two types of these ducts to be met with: large and small. What I call the large ducts have a wide, short tube and opening, and in some exotic species the openings are situated within a chitinous area. They are usually sparse, and appear to be more prevalent at the apical extremity of the body, or one or more may be found in close proximity to each of the cerarii. In the majority of the New Zealand species these large ducts are absent. The small tubular ducts have openings about the size of the triangular pores, and the tube is equally narrow. They are to be found in the majority of the endemic species, and are usually aggregated into clusters near the margin of the abdomen, though occasionally they are found in transverse bands. Owing to their small size they are very often hard to detect, and this detracts very much from their value. Both types of ducts should be looked for, and their presence or absence noted.

Derm setae.—These are usually present, and vary to a certain extent, but unless unusually numerous or large, are of very little taxonomic value. Their presence or absence, however, should always be noted.

Derm spines.—In at least one endemic species these take the place of the derm setae, and thus have a specific value. Their presence should always be noted.

Anal ring.—As far as this is concerned there appears to be no distinguishing fact in the endemic species. Some authors have placed reliance on the length and number of the setae on the anal ring, but these are found to vary considerably in specimens belonging to the same species. There is sometimes a slight difference in the arrangement of the pores composing the anal ring of different species.

Spiracles.—These appear to be of very little importance for the identification of the species.

Larva.

As far as the New Zealand species of the above genera are concerned, there appears to be very few distinguishing characters in the larva. The antenna have fewer joints, usually six, sometimes seven joints, but apart from this, there appears to be very few characters that can be made use of for taxonomic purposes.

Male.

Owing to their scarcity, and also to the great similarity noticed among the males of all species so far found, they appear to have no taxonomic value.

Secretions.

In the past too much reliance has been placed on the nature and disposition of the secretions of the living insects, and one consequence of this has been to increase the list of synonyms. As far as the New Zealand species of the genera are concerned, the secretions may be of two kinds: mealy or cottony, with the exception that *T. alpinus* Mask., which has a felted test similar to that of an *Eriococcus*. Again, too much reliance should not be placed on the colour of the secretion, as I have noticed in one subterranean species, for example, that the colour of the secretion in the young stage is white, while that of the adult is orange. The pencils of secretion,—such as are found in *P. longispinus* Targioni—have in the past often been used as a means of identification; but it must be borne in mind that there are several other New Zealand species with very similar pencils, consequently wrong identification is likely to occur.

Colour.

Very little reliance should be placed on the actual colour of the insect. The majority of the endemic species are of a pinkish colour, with a few species green, but this cannot be relied on, as I have found one species in which some of the specimens are green and

others red; moreover, it could not be said that the red specimens were a variety of the green, or vice-versa, as both colours have been found in the brood of a single female. It is therefore evident that the only really safe course to adopt when identifying later collections is to examine the prepared insect.

SYSTEMATIC TREATMENT.

As pointed out by Ferris (1918), a doubt exists as to the proper scientific term that should be applied to this group of insects, to which the vernacular term "mealy bugs" is commonly given. After a fairly close study of the endemic species, I have no hesitation in affirming that Ferris was correct in saying that the species in the genera under discussion form a natural group quite distinct from the remainder of the Coccidae, especially from such genera as *Eriococcus* and *Rhizococcus*, both of which are strongly represented in this country; but it is open to question as to whether this group should be placed as a tribe of the subfamily Dactylopinæ, as a subfamily, or as a family. As has been pointed out by others, all the members of the group have at least one pair of dorsal ostioles, which are not present in any other members of the family, and in the presence of cerarii, which, with few exceptions, are general within the group; moreover, the tubular ducts are different in shape from those found in the *Eriococcus*. For these reasons, and for the sake of clearness, I will hereafter in this paper refer to the group as a subfamily, Pseudococcinae, thus separating them from such other groups as will come under the Subfamily Eriococcinae.

The extent of the group thus defined is somewhat problematical, and need not concern us here except as regards the New Zealand members of the subfamily; and, judging from the material already collected, these, in all probability, can be included within the following six genera: *Antonina*, *Phenacoccus*, *Pseudococcus*, *Ripersia*, *Ripersiella*, and *Trionymus*.

GENERIC CONCEPTS.

As stated previously, the present generic concepts of this group are based almost wholly on the number of joints in the antenna. In the early days of the study of the Coccidae this may have appeared quite satisfactory for this group; but with the large number of species now being found throughout the world, and owing to the great variability that has since been found to take place in the antenna of the species belonging to the group, the uselessness of continuing this method of identification is obvious. It has therefore become necessary that other characters should be found to take the place of the antennal characters in identification, not only for generic, but for specific purposes also, and for this the cerarii will undoubtedly be found the most suitable. As far as the endemic species are concerned, the cerarii appear to be very constant within the species, and as long as a hard and fast rule is laid down as to what will constitute a cerarius, very little trouble should occur as far as the two main genera are concerned. For the further separation of the

genera, the absence of cerarii, and a different type of derm pore in place of the small triangular pore with a trilocular centre, would be of great assistance in separating off several species in this country, as was done by Ferris (1918) in California, when he erected a new genus on the basis of a quinquelocular derm pore. Whether or not the denticle on the claw could be used for the separation of species belonging to the genus *Phenacoccus*, I am unable to say, as this genus is not well represented in this country. However, as no other representative of the other genera in this group, as far as I am aware, possesses a denticle on the claw, this fact should be sufficient for separating off such species from the genus *Pseudococcus*.

Ferris (1918), in his diagnosis of the genus *Pseudococcus*, made the following statement: ". . . with not more than 17 pairs of cerarii and sometimes with not more than five distinct pairs. . . ." This was an oversight, and, I understand, was corrected later.

One peculiarity noticeable among the endemic species is, that while those species usually having a six-jointed antenna have less than ten pairs of cerarii and therefore belong to the genus *Trionymus*, those usually with a seven-jointed antenna have a full complement of from 16 to 18 pairs, and must be placed in the genus *Pseudococcus*.

As regards the separation of the different genera here set out, it will be noticed that I have not entirely abandoned the antennae, owing to the fact that to a certain extent they can be of use for further separation of the genera into groups, while at the same time using other and more important factors for the separation of the genera. I do not claim for the system here adopted that it will prove equally successful in other countries, but it is tentative as regards the species found in this country, and until the group can be examined as a whole.

For the information of those who make use of the key for identification, it should be borne in mind that it is to be used as an aid, and not as a final means of identification. By means of the key, a glance at the antenna will show in which primary division the specimen will be found if already named, and a further examination of the hind legs will at once place it in a certain group of that division; the number of cerarii, and spines in the ultimate cerarius, will show to which species in that particular group the specimen under consideration most nearly resembles, and any further reference required should be restricted to the text of those species. In very few instances will a comparison have to be made with more than one species.

In conclusion, I would like to thank all those who have assisted me in my studies. To Mr E. E. Green I am especially indebted for much advice and many specimens of foreign species. To Messrs Muggeridge and Cottier, of the Government Research Station, I am indebted for many specimens and much information, and also for the loan of any slides in the Maskell Type Collection that I required. I must also acknowledge the great assistance I have received from the Entomological staff of the Cawthron Institute, including the Assistant Director, Dr D. Miller. To these and to many others I tender my most sincere thanks.

KEY FOR THE IDENTIFICATION OF THE SPECIES OF THE GENUS
TRIONYMUS FOUND IN NEW ZEALAND.

A. Antenna usually of 6 joints.

(a) Pores on Hind Legs Absent:

Cerarii.	Cerarian abdom.	Spines: Frons.	Tubular ducts: Large.	Small.	Chitin- ized cerarii.	Name.
1	3	—	—	—	—	<i>montanus</i> sp. nov.
2	?	—	?	?	—	<i>fagi</i> Mask.
3	2	—	P	—	3	<i>raouliae</i> sp. nov.
4	2	—	P	—	—	<i>occultus</i> Brit.
4	2	—	P	P	1	<i>assimilis</i> sp. nov.
4	2	—	—	P	1	<i>dendrobii</i> sp. nov.
5-6	4	—	P	—	1	<i>otagoensis</i> sp. nov.

B. Antenna usually of 8 joints.

(a) Pores on Hind Legs Absent:

1	2	—	—	P	—	<i>aurilanatus</i> Mask.
1	2	—	—	—	—	<i>drimydis</i> sp. nov.
2	3	—	—	P	—	<i>obtectus</i> Mask.
3	2	3-4	—	P	1	<i>morrisoni</i> sp. nov.
4	2	—	P	—	1	<i>oamaruensis</i> Brit.
4	2	—	—	P	1	<i>cottieri</i> sp. nov.
4	6	—	—	P	—	<i>alpinus</i> Mask.
4	7	—	—	P	1	<i>chiltoni</i> sp. nov.
6	2	—	P	P	—	<i>insolitus</i> sp. nov.

(b) Pores on Hind Coxa only:

1	2	—	—	P	—	<i>dissimilis</i> sp. nov.
2	2	—	—	P	—	<i>danthoniae</i> Morr.
2	2	—	—	P	—	<i>diminutus</i> Leon.
3	2	—	—	P	—	<i>diminutus-cordylinidis</i> subsp. nov.
4	2	—	—	P	1	<i>canalis</i> sp. nov.
4	6	—	—	—	—	<i>sewaspinus</i> Brit.
4	11	—	P	—	1	<i>iceryoides</i> Mask.
7	2	—	P	P	—	<i>leucopogi</i> sp. nov.

(c) Pores on Hind Coxa and Tibia:

3	2	—	P	P	—	<i>coriariae</i> sp. nov.
6	2	—	P	P	—	<i>zealandicus</i> sp. nov.

(d) Pores on Hind Femora and Tibia:

4	2	—	P	P	—	<i>mammillariae</i> Bouche
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(e) Pores on Hind Tibia only:

1	2	—	P	P	—	<i>podocarpi</i> sp. nov.
5	4	3	—	P	2	<i>ambiguus</i> Morr.

Abbreviation—P = present.

Genus TRIONYMUS Berg.

Genotype: *Westwoodia perrissii* Signoret.

Pseudococcinae forms with at least one pair of dorsal ostioles. Antenna of six to nine joints. With not more than ten distinct pairs of cerarii present, each cerarius to consist of one or more spines surrounded by a more or less definite cluster of triangular pores, and with or without accessory setae. In the absence of definitely clustered pores, then a cerarius to consist of at least two closely-contiguous spines easily recognised by their shape and size

from other derm spines or setae, and situated in the proper position for a cerarius. Small triangular pores with trilocular centres present. Large circular disc pores present or absent. Large and small tubular ducts present or absent. Derm setae usually present, but may be replaced by derm spines.

Trionymus montanus sp. nov.

Adult female situated within a small gall formed on the fan-shaped phylloclads of the plant, ovate. Antenna of six joints, last joint longest, formula: 6,3(1,2)(4,5). Rostrum normal, mentum as broad as long. Legs short and thick, tibia slightly longer than tarsus; pores on hind legs absent. With only one distinct pair of cerarii, each with three small spines, a few loosely-clustered triangular pores, without accessory setae. Derm pores of two types: small triangular with trilocular centres, sparse; and a few large disc pores close to anal ring. Large and small tubular ducts not observed. Derm setae not observed. Length about 1.70 mm.; width 1.14 mm.

Hab.—In small gall on *Phyllocladus* sp., Otira, 28/12/15.

Type slides in own collection.

The unusual habitat of this species rather puzzled me at first, but apart from the somewhat shortened legs, and the absence of setae, there is nothing else which would warrant the erection of a new genus, as the antenna and cerarii are quite normal.

Trionymus fagi Maskell.

1890. *Rippersia fagi* Mask., *Trans. N.Z. Inst.*, vol. xxiii, p. 24.

Adult female elongate-ovate. Antenna of six joints, last joint longest, formula: 6,3,1,2,5,4. Rostrum normal, mentum broader than long. Legs rather short and thick, tibia not quite twice length of tarsus; pores on hind coxa only observed. Two definite pairs of cerarii only observed; ultimate pair each with probably five to seven long thin spines and a close cluster of pores; penultimate pair each with four or five somewhat smaller spines and a close cluster of pores. Accessory setae not observed. Derm pores of two types: small triangular very plentiful, and large disc in about four single rows which do not reach the margin of the body. Large tubular ducts not observed; small tubular ducts not observed. Derm setae present, sparse. Length about 1.86 mm.; width about 1.32 mm.

Hab.—On *Nothofagus menziesii*, Reefton.

Type slide in Maskell Collection.

Described from one slide in the Maskell Collection dated 1890. There is also another slide labelled "early second stage," of the same date, but the only fact I was able to make out was that there were six spines on the ultimate cerarius. Both slides are unstained, and many characteristics cannot be fully made out, but there can be no doubt that the species is rightly included in this genus. Apart from the six-jointed antenna, this species does not agree with any other endemic species of which I have knowledge.

Trionymus raouliae sp. nov.

Insects covered with a thin yellow mealy secretion, subterranean. Adult female dark purple, ovate. Antenna of six joints, last joint longest, formula: 6(1,3)2(4,5), all joints with the usual long setae. Rostrum normal, mentum longer than broad. Legs normal, tibia not quite twice length of tarsus; all joints with very long, stout setae; pores on hind legs absent. With three distinct pairs of cerarii, each surrounded by a small chitinized area, that on the ultimate cerarius being the largest: ultimate pair each with two stout spines, four accessory setae, and a loose group of pores; remaining cerarii each with two stout spines, two accessory setae, and a small cluster of pores; the spines on all the cerarii approximately equal in size. Derm pores of two types: small triangular evenly spaced, and large disc in about one irregular band. Large tubular ducts only observed. Derm setae fairly plentiful, rather large. Length about 2.58 mm.; width about 1.77 mm.

Hab.—On *Raoulia* sp., on riverbed, Maruia Springs, 3/11/35.

Type slides in own collection, No. 262.

This species may very easily be mistaken for *R. globatus* Brit., when mounted, but differs in the number of cerarii and in the absence of pores on the hind coxa. When in the natural state it differs in the colour of the secretion.

Trionymus occultus Brittin.

1914. *Ripersia occultum* Brit., *Trans. N.Z. Inst.*, vol. xlvii, p. 155.

Adult female elongate-ovate, colour dark-purple, covered with a thick yellow mealy secretion. Antenna of six joints, last joint longest, formula: 6,1,3(2,5)4. Rostrum normal, mentum longer than broad. Legs stout, tibia nearly twice length of tarsus, pores on hind legs absent. With four distinct pairs of cerarii, each with two stout spines, two or three accessory setae, and a loose cluster of triangular pores. Derm pores of two types: small triangular evenly spaced, and large disc in several transverse bands on the abdomen. Large tubular ducts only observed. Derm setae present, long and stout, most numerous on frons. Length about 1.53 mm.; width about 0.92 mm.

Hab.—On roots of grass, Oamaru, 14/7/13.

Type slide in own collection, No. 12.

Differs from *T. raouliae* n.sp. in its more elongate form, its smaller size, an additional pair of cerarii, and with smaller spines on all the cerarii anterior to the ultimate pair.

Trionymus assimilis sp. nov.

Adult female elongate-ovate, covered with a white mealy secretion. Antenna of six joints, last joint longest, formula: 6(2,3)1,5,4. Rostrum normal, mentum longer than broad. Legs stout, tibia twice length of tarsus, pores on hind legs absent. With four distinct pairs of cerarii, each with two stout spines, about four accessory setae, and a loose cluster of triangular pores; the ultimate pair of cerarii

slightly chitinized. Derm pores of two types: small triangular evenly spaced, and large disc in transverse bands on abdomen. Large tubular ducts present, sparse; small tubular ducts present, sparse. Derm setae present, long and stout. Length about 2.40 mm.; width about 1.45 mm.

Hab.—On *Poa*, Christchurch, 15/6/16.

Type slides in own collection, No. 27.

This species differs from the last-named in its larger size, the differently coloured secretion, in the ultimate pair of cerarii being slightly chitinized, and in the presence of both large and small tubular ducts.

***Trionymus dendrobii* sp. nov.**

Adult female ovate, secretion orange-yellow. Antenna of six joints, last joint longest, formula 6,3,1,2,5,4. Rostrum normal, mentum not observed. Legs long and stout, tibia nearly twice length of tarsus, claw thin and narrow at base, pores on hind legs absent. With four distinct pairs of cerarii: the ultimate pair slightly chitinized, with two stout spines, about four accessory setae, and a loose cluster of pores; remaining cerarii not chitinized, with two similar spines, a small cluster of pores, but without recognisable setae. Derm pores of one type only observed, small triangular, very plentiful. Derm setae present, very plentiful, long and stout. Small tubular ducts only observed. Length about 2.0 mm.; width about 1.50 mm.

Hab.—On roots of *Dendrobium*, under moss, Westport, 11/10/35.

Type slide in own collection, No. 265.

Somewhat resembles *T. raouliae* n.sp., but differs in having an additional pair of cerarii of which only the ultimate pair is chitinized, by the presence of large tubular ducts, and the absence of large disc pores.

***Trionymus otagoensis* sp. nov.**

Adult female ovate, subterranean. Antenna of six joints, last joint longest, formula: 6,3,1,2,5,4. Rostrum normal, mentum longer than broad. Legs stout, rather large, tibia nearly twice length of tarsus; pores on hind legs absent. With five to six definite pairs of cerarii: ultimate pair each with two large and three small spines, about two accessory setae, and a loose cluster of pores; remaining cerarii each with two stout spines and a few grouped triangular pores, but with accessory setae. Ultimate pair of cerarii lightly chitinized. Derm pores of two types: small triangular evenly spaced and large disc in irregular transverse bands at abdomen. Large tubular ducts present; small tubular ducts not observed. Derm spines present, rather numerous, of various sizes. Derm setae present, sparse. Length about 2.52 mm.; width about 2.0 mm.

Hab.—On *Poa*, Oamaru, 3/10/13.

Type slides in own collection, No. 309.

Very close to *T. assimilis*, but differs in having large tubular ducts only, and also in the presence of derm spines.

Trionymus aurilanus Maskell.

1890. *Dactylopius aurilanus* Mas., *Trans. N.Z. Inst.*, vol. xxii, p. 151.

1918. *Pseudococcus aurilanus* (Mas.), Ferris, *Stanford Univ. Ser.* p. 38.

Adult female elongate-ovate, dark-red, covered with a yellow, waxy secretion arranged in tufts on the dorsum and along the margin. Antenna of eight joints, last joint longest, formula: 8,3,1,7(5,6)4. Rostrum normal, mentum longer than broad. Legs normal, tibia nearly twice length of tarsus, pores on hind legs absent. With only one definite pair of cerarii, each with two narrow spines, three accessory setae, and a few loosely clustered pores. Derm pores of two types: small triangular fairly numerous, and large disc in about six irregular transverse bands at abdomen. Derm setae present, sparse. Derm spines present on dorsum, small, most numerous at cephalic extremity. Large tubular ducts not observed; small tubular ducts present, not numerous, scattered. Length about 2.0 mm.; width about 1.26 mm.

Hab.—On *Araucaria bidwelli*, ex Maskell collection.

Type slide in Maskell Collection.

Very close to *T. drimydis* Mask., from which it can be separated by the presence of derm spines. Ferris (1918) placed this species in the genus *Pseudococcus*, but stated that it was nearer *Erium* or *Trionymus* than *Pseudococcus*. He also mentioned that it had five or six pairs of cerarii, but that the spines in the anteriormost pairs were so widely separated as to be scarcely recognisable.

Trionymus drimydis sp. nov.

Adult female elongate, dark-red. Antenna of eight joints, last joint longest, formula: 8(2,3)1,4,7(5,6). Rostrum normal, mentum slightly longer than broad. Legs normal, stout, tibia two and a-half times length of tarsus; pores on hind legs absent. Only one definite pair of cerarii: each with two stout spines, two accessory setae, and a loose cluster of triangular pores. Derm pores of two types: small triangular evenly spaced, and large disc in irregular transverse bands on abdomen, they appear to be confined to the median area, and do not reach the margin of the body. Large and small tubular ducts not observed. Derm setae present, medium length, and apparently in bands on abdomen. Length about 3.30 mm.; width about 1.80 mm.

Hab.—On *Drimys colorata*, Christchurch, 2/12/16.

Type slide in own collection, No. 104.

As regards the number of cerarii this species resembles *T. aurilanus* Mask., but differs in the colour and nature of the secretion, and also in the absence of derm spines.

Trionymus obtectus Maskell.

1890. *Dactylopius obtectus* Mask., *Trans. N.Z. Inst.*, vol. xxii, p. 152.

1922. *Pseudococcus obtectus* (Mask.), Myers, *Jour. Sci. and Tech.*, vol. v, No. 4, p. 198.

Adult female concealed beneath the bud-scale of the plant, elongated, almost pyriform in shape, with anal lobes more prominent than is usual in the genus. Antenna of eight joints, last joint longest, formula: 8(1,2)(3,7)6,5,4 and 8(1,2)7(3,6)5,4. Rostrum normal, mentum longer than broad. Legs normal, tibia nearly twice length of tarsus, pores on hind legs not observed. Two distinct pairs of cerarii: ultimate pair each with five somewhat small spines, about three accessory setae and a loose cluster of seven or eight triangular pores; penultimate pair each with two similar spines and a few loosely-clustered pores. The body of the insect narrows towards the abdominal lobes, which are more prominent than is usual in the genus. Derm pores of two types: small triangular, sparse; and large disc in about four transverse rows, disc pores in each row equidistant. Large tubular ducts not observed, small tubular ducts numerous over whole body. Derm setae present, sparse, rather long and fine. Length about 1.11 mm.; width across cephalothoracic portion 0.72 mm.

Hab.—On *Nothofagus fusca*, ex Maskell Collection. On *Nothofagus fusca*, Motueka, in own collection.

Cotype slide in Maskell Collection.

The somewhat pyriform shape with its narrow abdomen and prominent lobes, also the single rows of large disc pores, sufficiently distinguish this species from any other endemic species of the genus. As the Maskell slide was not to be found in the Maskell Collection, through the courtesy of the Government Entomologist I was allowed to mount a slide from the scanty spare material that was discovered, and this slide is now in the collection. Since then I have rediscovered the species on some Beech trees at Motueka.

Trionymus oamaruensis Brittin.

1915. *Pseudococcus oamaruensis* Brit., *Trans. N.Z. Inst.*, vol. xlvii, p. 153.

1893. *Dactylopius arecae* Mask. (in part), *Trans. N.Z. Inst.*, vol. xxv, p. 231.

1922. *Pseudococcus oamaruensis* (Brit.): Myers, *N.Z. Jour. Sci. and Tech.*, p. 198.

Adult female elongate, convex above, flat beneath, colour brick-red, covered with a thin yellow meal. Antenna of eight joints, last joint longest, formula: 8,2,1(3,5)(6,7)4. Rostrum normal, mentum longer than broad. Legs normal, tibia nearly twice length of tarsus, pores on hind legs absent. With four definite pairs of cerarii, the ultimate pair being lightly chitinized, with two somewhat lanceolate spines, about four accessory setae, and a loose cluster of triangular pores; the next two pairs with two spines, and the foremost each with one spine, each cerarius with a few clustered pores. Derm pores of two types: small triangular evenly spaced, and large disc in apparently a single transverse band about anal orifice. Derm

setae present, long, most numerous at cephalic extremity. A few large tubular ducts present; small tubular ducts not observed. Length about 2.52 mm.; width about 1.72 mm.

Female of second instar similar to adult. Antenna of six joints, last joint longest. Rostrum normal, mentum longer than broad. Legs normal, tibia and tarsus about equal. With only three definite pairs of cerarii, each with two spines but without any definitely clustered pores. Derm pores apparently of two types: small triangular widely spaced and what appear to be a few disc pores just above anal ring. Derm setae present, similar to that of adult. Tubular ducts not observed. Length about 2.0 mm.; width about 1.12 mm.

Hab.—Subterranean, on roots of various plants in garden, Oamaru.

Type slide in own collection, No. 11.

This species is present in the Maskell Collection under the name *Dactylopius arecae*. There are four slides under this name in the collection, three of which (one of adult female dated 1892; one preadult female 1892; one portion of female 1893) undoubtedly belong to this species. One other slide under the name of *Dactylopius arecae* dated 1893 shows the anterior half of the body, and, as there are a number of cerarii showing, it is obvious that the insect belong to the genus *Pseudococcus*, with a complete series of cerarii, moreover, the small triangular pores are very numerous on this specimen, whereas in *T. oamaruensis* they are widely spaced. Maskell first reported *D. arecae* Mask. in 1889 on the roots of Nikau palm at Wellington, it is therefore evident that none of the slides mentioned here could have been types. He afterwards reported the species as on the roots of various cultivated plants at Ashburton in 1893, and it is probable that the slides now in the collection were taken from the later finding. As Maskell's original description is quite useless for the purpose of identification, and seeing that there are now several species with the same coloured secretion, I have thought best to retain my original name for the three slides above mentioned, leaving the fourth slide provisionally under the name *P. arecae* Mask. until this species is rediscovered in its original habitat.

[Note.—Disc pores are not usually found in second instar. The supposed second instar may prove to be a distinct species.]

Trionymus morrisoni sp. nov.

Adult female elongate, green, covered with a thin white meal. Antenna of eight joints, last joint longest, formula: 8(1,3)2(5,7)6,4, all joints with very long setae. Rostrum normal, mentum longer than broad. Legs normal, stout, tibia more than twice length of tarsus, pores on hind legs not observed. With three distinct pairs of cerarii, two of which are on frons between antennae: abdominal pair each with two long stout spines, about four accessory setae, and a large loose cluster of pores; cerarii on frons with three to four small pores and a few loosely clustered pores without accessory setae. The abdominal pair of cerarii appear to be lightly chitinized. Derm

pores of two types: small triangular most plentiful at either extremity and large disc in about four single rows on abdomen, the ends of which do not reach the margin of the body. Large tubular ducts not observed, small tubular ducts present, sparse. Derm setae present. Length about 3.20 mm.; width about 1.52 mm.

Hab.—On *Alectryon excelsum*, Motueka, 9/11/37.

Type slides in own collection.

A rather unusual species, and with the exception of one other species, *T. ambiguus* Morr., the only member of the genus in New Zealand with cerarii on the cephalic portion of the body. It differs from the latter species in having fewer cerarii, in having only one pair on the abdomen, while there are two pairs between the antennae; it also differs from *T. ambiguus* in being of a green colour in its tremity, and large disc in about four single rows on abdomen, the natural state. I have much pleasure in naming this species after Mr Harold Morrison of the Biological Department, U.S.A., from whom I have received much assistance.

***Trionymus cottieri* sp. nov.**

Adult female elongate-ovate, very active, colour dirty white, covered with a thick white cottony secretion in which the insects in the early stages appear to form tunnels, and from which they emerge soon after the leaf has been picked. The secretion is always deposited on the under surface of the leaf. Antenna of eight joints, last joint longest, formula: 8(1,2,5,7)3(4,6). Rostrum normal, mentum longer than broad. Legs normal, tibia about twice length of tarsus, claw with a thin, narrow base; pores on hind legs not observed. With four definite pairs of cerarii: ultimate pair each with two long narrow spines, about three accessory setae, and a loose cluster of pores; the remaining cerarii each with two thin spines and two or three pores, but without accessory setae. Derm pores of two types: small triangular, sparse, and large disc, very numerous and scattered over whole body. Large tubular ducts not observed; small tubular ducts numerous, and found scattered over whole body. Derm setae present: sparse on abdomen, long and plentiful on frons. Length about 1.55 mm.; width about 0.85 mm.

Hab.—On *Nothofagus Menziesii*, Wanganui, Motueka, Maruia.

Type slide in own collection.

I have much pleasure in naming this species after Mr W. Cottier of the Plant Research Station, from whom I first received living specimens. I had first noticed the secretion of this species on *Nothofagus* on the Takaka Hills, and with a weak magnifying glass had been able to see that there were insects underneath the secretion. However, when examining the secretion again with the intention of preparing specimens for mounting, I could not find any. As regards the large number of disc pores scattered all over the body, this species somewhat resembles *T. diminutus* Leon., but differs in not having pores on the hind legs.

Trionymus alpinus Maskell.

1884. *Dactylopius alpinus* Mask., *Trans. N.Z. Inst.*, vol. xvi, p. 138.

Adult female enclosed within a closely-felted sac similar to that of an *Eriococcus*, old dried examples dark-red, almost black, very convex on dorsum, flat beneath, the insect when mounted on a slide appearing almost circular. Antenna of eight joints, last joint longest, formula: 8(1,2)(3,6,7)5,4. Rostrum normal, mentum broader than long. Legs normal, tibia twice length of tarsus, pores on hind legs not observed. With four definite pairs of cerarii, the two posterior pairs being slightly chitinized: ultimate pair each with three large and three small spines, two or three accessory setae, and a loose cluster of triangular pores; the penultimate pair each with two large and three small spines and a loose cluster of pores, but without accessory setae; the remaining two pairs of cerarii each with two large spines and a few clustered pores. The last three abdominal segments each with a transverse row of large stout spines similar to those on the cerarii. Derm pores of two types: small triangular evenly spaced, and large disc in about four transverse bands on abdomen. Large tubular ducts not observed; small tubular ducts present. Length about 3.06 mm.; width about 3.04 mm.

Hab.—On *Veronica* sp., ex Maskell Collection.

Described from two co-type slides in the Maskell Collection.

The closely-felted sac of the adult female, together with the transverse rows of stout spines, clearly distinguishes this species from any other endemic species.

Trionymus chiltoni sp. nov.

Adult female elongate-ovate, dark-red. Antenna of eight joints, last joint longest, formula: 8,2,1(3,7)(5,6)4. Rostrum normal, mentum as broad as long. Legs normal, tibia one-third longer than tarsus; pores on hind legs not observed. With four definite pairs of cerarii: ultimate pair each with three very large and four small spines and a few loosely-clustered pores; remaining cerarii each with two large and one smaller spine and a few clustered pores; no accessory setae observed. Derm pores of two types: small triangular widely spaced, and large disc in about six short double transverse rows which do not reach the margin of the body. A few large tubular ducts observed at cephalic extremity; small tubular ducts numerous over whole body. Derm spines present; there being three transverse segmental rows at abdomen, with numerous small spines scattered on remainder of body. Derm setae not observed. Length about 2.60 mm.; width about 1.82 mm.

Hab.—On *Leucopogon* sp., Cass, Canterbury.

Type slides in own collection.

I have much pleasure in naming this species after its discoverer, the late Dr Charles Chilton, who was kind enough to send me the specimens discovered during one of his trips to the Cass. It is a very distinct species, and in some respects resembles *T. alpinus* Mask.,

which was also discovered in the same district. It differs from that species in the number of spines in the cerarii, by the absence of derm setae, and by the presence of large tubular ducts at the cephalic extremity.

***Trionymus insolitus* sp. nov.**

Adult female elongate-ovate, dark-red, covered with a thin white meal. Antenna of eight joints, last joint longest, formula: 8(1,2,3)(5,6,7)4. Rostrum normal, mentum longer than broad. Legs normal, tibia two and a-half times length of tarsus; pores on hind legs not observed. With six definite pairs of cerarii: the ultimate pair slightly chitinated, and each with two stout spines, about seven accessory setae, and a loose cluster of triangular pores; the remaining cerarii each with two stout spines and a few clustered pores, without accessory setae. Derm pores of two types: small triangular, very plentiful, and large disc in about five transverse segmental bands, the ends of which do not reach the margin of the body. Large tubular ducts present, there being one opposite each of the cerarii, small tubular ducts present on abdomen near margin. Derm setae present in various sizes over whole body. Length about 2.30 mm.; width about 1.12 mm.

Hab.—On unknown plant, Maruia Hot Springs.

Type slide in own collection, No. 258.

A very distinct species that can hardly be mistaken for any other endemic species.

***Trionymus dissimilis* sp. nov.**

Adult female very elongate, apparently naked, colour light green, turns red in boiling caustic potash. Antenna of eight joints, last joint longest, formula: 8,1,2(5,7)(3,6)4. Rostrum normal, mentum slightly broader than long. Legs normal, stout, tibia twice length of tarsus; pores on hind coxa only. With one definite pair of cerarii, each with two stout spines and a few loosely-clustered pores, but without any recognisable accessory setae. Derm pores of two types: small triangular evenly spaced, and large disc in about four narrow transverse segmental bands reaching the margin of the body. Large tubular ducts not observed; small tubular ducts present. Derm setae present, short and fine on dorsum, longer on ventral surface. Length about 5.62 mm.; width about 2.0 mm.

Hab.—On dead leaves on ground, Oamaru; on *Coprosma* sp., Riwaka, Nelson.

Type slides in own collection, No. 10.

In colour this species greatly resembles *P. glaucus* Mask., for which I at first mistook it until I had examined the Maskell types; it differs, however, in having only a single pair of cerarii, each with two spines, and also in the presence of pores on the hind coxa.

Trionymus danthoniae Morrison.

1925. *Trionymus danthoniae* Morr., *Jour. Agric. Res.*, vol. xxxi, No. 5, Sept., p. 494.

1884. *Dactylopius calceolariae* Mask. (in part), *Trans. N.Z. Inst.*, vol. xvi, p. 100.

Adult female with antenna of eight joints, second joint longest, formula: 2,8,1,5,(3,4)7,6. Rostrum normal, mentum as broad as long. Legs normal, stout, tibia twice length of tarsus; with a large group of pores on hind coxa. With two definite pairs of cerarii, each with two stout spines, about four accessory setae, and a few loosely-clustered pores. Derm pores of two types: small triangular, very plentiful, and large disc in about three transverse band on abdomen with others scattered over body up to a level with the rostrum. Large tubular ducts not observed; small tubular ducts present, most noticeable at margin of body. Derm setae present, most numerous at cephalic extremity. Length about 5.64 mm.; width about 2.40 mm.

Hab.—On *Danthonia* sp., Stewart Island.

Type slide in Maskell Collection.

Described from one slide in the Maskell Collection labelled

Dactylopius calceolariae, dated September, 1880.

Although this species was described by Morrison from two specimens in the Maskell Collection, it is very doubtful if it is sufficiently distinct from *T. diminutus* Leon. to constitute a new species. From discoveries that have been made during the last few years, it is now very evident that there are several varieties of *T. diminutus*, one of which is found on *Cordyline*, and another on the common rush. In all the varieties the large disc pores are found scattered over the body, although to a slightly different extent according to the plants on which the insects are found. In each case the small triangular pores are numerous, but also varying slightly according to the plant habitat; and in each instance the mentum is as broad as long. Practically the only distinctive point in *T. danthoniae* is found in the second joint of the antenna, which is longer than the eighth joint.

Trionymus diminutus Leonardi.

1884. *Dactylopius calceolariae* Mask. (in part), *Trans. N.Z. Inst.*, vol. xvi, p. 138.

1925. *Trionymus diminutus* (Leon.) Morr., *Jour. Agric. Res.*, vol. xxxi, No. 5, p. 495.

Adult female elongate-ovate, pink, rather flat, covered with a thin white mealy secretion. Antenna of eight joints, last joint longest, formula: 8,2,1(3,5)(4,7)6. Rostrum normal, mentum as broad as long. Legs normal, stout, tibia more than twice length of tarsus; large group of pores on hind coxa. With two definite pairs of cerarii: ultimate pair each with two stout spines, about four accessory setae, and some very loosely clustered pores; penultimate pair each with two similar spines and a few loosely clustered pores. Derm pores of two types: small triangular, very numerous; and large disc also very numerous and found scattered all over the

body, there being some found between the antennae and on both dorsal and ventral surfaces. Large tubular ducts apparently absent; small tubular ducts present. Derm setae present, of two sizes, most numerous at cephalic extremity. Length about 4.90 mm.; width about 2.25 mm.

Hab.—On *Phormium tenax*, Oamaru, Christchurch, Nelson.

There are at least two other forms of this species, one of which is found on *Cordyline australis*, and differs from that found on *Phormium* in always possessing three pairs of cerarii; it is also, on the average, slightly smaller than those found on *Phormium*, and the large disc pores do not seem to be quite so plentiful, but are still found between the antennae. Although the average size on *Cordyline* is smaller, the antennae average longer. These differences justify systematic recognition, so the name *Trionymus diminutus cordylinidis* subsp., nov. is proposed.

The variety found on rushes is the smallest, averaging about half that found on *Phormium*, and the antennae are equally short. There are only two pairs of cerarii, exactly similar to those of the variety found on *Phormium*. The large disc pores are more numerous than on either of the other two varieties, but are not to be found above the level of the rostrum, and in this last fact it resembles *T. danthoniae* Morr., although the adult female averages smaller than that species. In all these varieties there is a large group of pores on the hind coxa, and the mentum is as broad as long.

***Trionymus canalis* sp. nov.**

Adult female short ovate, dark-red, turning purple on maceration in caustic potash. Antenna variable, of eight joints, last joint longest, formula: 8,2,3(15)7,4,6. Rostrum normal, mentum longer than broad. Legs normal, stout, tibia two and a-half times length of tarsus; pores on hind coxa only observed. With four definite pairs of cerarii: ultimate pair lightly chitinized, and each with two stout spines, a large group of triangular pores and several accessory setae; remaining cerarii each with two small spines and a small group of pores without accessory setae. Derm pores of two types: small triangular, numerous, and large disc very numerous over whole body. Large tubular ducts not observed; small tubular ducts numerous. Derm setae present, long and fine. Length about 3.40 mm.; width about 2.15 mm.

Hab.—On *Discaria*, under moss, in tunnels made by ants, Mauria Hot Springs.

Type slides in own collection, No. 264.

Very close to *T. insolitus* n.sp., but differs in having fewer cerarii, in the smaller cerarian spines, in the large number of disc pores, and in the presence of pores on the hind coxa. From *T. diminutus* and varieties, it differs in having the mentum longer than broad, and in the larger number of cerarii.

Trionymus sexaspinus Brittin.

1915. *Pseudococcus sexaspinus* Brit., *Trans. N.Z. Inst.*, vol. xlvii, p. 154.

Adult female elongate-ovate, pale pink, covered with a white cottony secretion, subterranean. Antenna of eight joints, last joint longest, formula: 8,1,2(5,7)6(3,4). Rostrum normal, mentum as broad as long. Legs normal, stout, tibia twice length of tarsus; pores on hind coxa only observed. With four definite pairs of cerarii: ultimate pair each with six stout spines, about three accessory setae, and a loose cluster of pores; penultimate pair each with two—sometimes three—stout spines and one or two pores, but no recognisable accessory setae; the remaining two pairs each with a single stout spine, but no recognisable setae or clustered pores. Derm pores of two types: small triangular or subtriangular, evenly spaced, and large disc in about five broad bands on abdomen, and also with a few scattered on frons. Large tubular ducts not observed; small tubular ducts present. Derm setae present, long and fine. Length about 3.50 mm.; width about 2.20 mm.

Hab.—On roots of sedge, Reefton, N.Z.

Type slides in own collection, No. 35.

A very distinct species as far as the number of spines in the cerarii are concerned. I have, in this species, somewhat departed from my rule as regards the cerarii, inasmuch as I have reported a single spine without grouped pores as a cerarius. My reason for this is that the spine is very large—in fact as large as any found in the ultimate cerarius, and each spine is in the proper place for a cerarius.

Trionymus iceryoides Maskell.

1892. *Dactylopius iceryoides* Mask., *Trans. N.Z. Inst.*, vol. xxiv, p. 33.

1922. *Pseudococcus iceryoides* (Mask.): Myers, *N.Z. Jour. Sci. and Tech.*, vol. v, No. 4, p. 198.

Antenna of eight joints, last joint longest, formula: 8,1,2(3,7)6,5,4. Rostrum normal, mentum slightly longer than broad. Legs rather small and thick, tibia about one and a-half times length of tarsus; hind coxa with a large group of pores. With four definite pairs of cerarii: ultimate pair on a slightly chitinated oval plate, each with three large and about eight small spines, but without any definite clustered pores or accessory setae; the remaining three pairs of cerarii each with two spines without setae or clustered pores. Derm pores of two types: small triangular very numerous, in bands at abdomen, and continued along margin of body, and large disc in about five transverse bands on abdomen. Large tubular ducts present; small tubular ducts not observed. Derm setae present at both extremities, long and fine. Scattered derm spines present. Length about 4.0 mm.; width about 3.0 mm.

Hab.—On *Nothofagus fusca*, Reefton.

Type slides in Maskell Collection.

Preadult female very similar to adult. Antenna of seven joints, formula: 7,1(2,3,4,6)5. Rostrum and mentum normal. Legs short and thick, tibia and tarsus about equal. With four pairs of cerarii exactly similar to those of adult. Derm pores of one type only observed, small triangular. Derm spines present, sparse.

Described from one slide of adult female in the Maskell Collection dated 1891, and one slide of preadult female dated 1891, and compared with slides in own collection, No. 44.

***Trionymus leucopogi* sp. nov.**

Adult female elongate-ovate, covered with a fairly thick white secretion. Antenna of eight joints, last joint longest, formula: 8,1,2,3(4,7)5,6. Rostrum normal, mentum longer than broad. Legs normal, stout, tibia more than twice length of tarsus; pores on hind coxa only observed. About seven definite pairs of cerarii: ultimate pair each with two long narrow spines, about three accessory setae, and a loose cluster of triangular pores; remaining cerarii each with two close-set fine spines and a few pores, but without accessory setae. Derm pores of two types: small triangular, evenly spaced, and large disc in about five transverse segmental rows on abdomen. Large tubular ducts present, small tubular ducts present, very numerous on abdomen, being in broad transverse segmental bands. Derm setae present, of various sizes. Length about 2.30 mm.; width about 1.24 mm.

Hab.—*Leucopogon fasciculata*, East Coast, Waihi.

Type slides in own collection, No. 246.

A very distinct species and not easily mistaken for any other endemic species.

***Trionymus coriariae* sp. nov.**

Adult female elongate-ovate when mounted, colour and secretion not known. Antenna of eight joints, last joint longest, formula: 8,2(1,3)(5,7)(4,6). In all specimens examined the antenna remained very constant. Rostrum normal, mentum nearly twice as long as broad. Legs normal, stout, tibia nearly three times length of tarsus; pores on hind coxa and tibia observed—the group of pores on the coxa is very large, covering nearly the whole joint. With three definite pairs of cerarii: ultimate pair each with three long stout spines, about four accessory setae, and a loose cluster of pores; penultimate pair each with two small spines and about nine triangular pores, but without accessory setae; the remaining pair with two very long thin spines and about seven triangular pores. Derm pores of two types: small triangular, evenly spaced, and large disc in broad transverse bands on abdomen. A few large tubular ducts present; small tubular ducts present in transverse bands on abdomen. Derm setae present, sparse. Length about 3.72 mm.; width about 2.0 mm.

Hab.—On roots of *Coriaria* sp., Aramoho, N.Z.

Type slides in possession of Dr D. Miller.

Described from four mounted specimens in the collection of Dr D. Miller. It is apparently closely related to *T. zealandicus* n.sp., from which it can be separated by the much larger group of pores on the hind coxa, the number and nature of the cerarii, and the difference in habitat (subterranean).

***Trionymus zealandicus* sp. nov.**

Adult female short ovate, very convex on dorsum. Antenna of eight joints, last joint longest, formula: 8,3,2,1,5(4,7)6. Rostrum normal, mentum nearly twice as long as broad. Legs normal, stout, tibia more than twice length of tarsus; pores on hind coxa and tibia observed. With six definite pairs of cerarii: ultimate pair each with two large stout spines, about six accessory setae, and a large loose cluster of pores; remaining cerarii each with two small spines and a small cluster of pores, but without accessory setae. Derm pores of two types: small triangular, evenly spaced; and large disc, very numerous at abdominal extremity, with a few more found scattered over the ventral surface as far as the antennae. Large tubular ducts present, sparse; small tubular ducts present, numerous, in transverse bands at abdomen. Derm setae present, long and fine. Length about 3.70 mm.; width about 2.40 mm.

Hab.—On unknown plant, Otira, N.Z. On *Podocarpus ferruginea*, Ngatea, N.Z.

Type slides in own collection, No. 99.

Differs from *T. coriariae* n.sp. in the larger number of cerarii, in the more numerous large disc pores, and in the smaller group of pores on the hind coxa.

***Trionymus mammillariae* Bouché.**

Adult female elongate-ovate, colour pink, covered with a thin white secretion. Antenna of eight joints, last joint longest, formula: 8,1(2,3)(4,5,7)6. Rostrum normal, mentum longer than broad. Legs normal, stout, tibia nearly two and a-half times length of tarsus; with a large group of pores on hind coxa and a small compact group of pores on hind tibia about two-thirds down. With four definite pairs of cerarii: ultimate pair each with two long narrow spines, three accessory setae, and a loose cluster of pores; remaining cerarii each with two small narrow spines and about six clustered pores, but without accessory setae. Derm pores of two types: small triangular, evenly spaced, and large disc in about five irregular transverse rows on abdomen. Large tubular ducts present; small tubular ducts present, very numerous, in bands on ventral surface of abdomen. Derm setae present, long and fine. Length about 2.25 mm.; width about 1.30 mm.

Hab.—On cactus, Nelson.

I have been unable to get the synonymy of this species, and had to depend on Green's somewhat meagre description—afterwards supplemented by correspondence—for its identification. Green mentions that Bouché wrote the specific name *mammillariae* with only

two "m's," although the correct name of the host is *Mammillaria*. This species is easily recognised by the large group of pores on the hind coxa and the very small compact group on the hind tibia, which latter group is quite unlike that of any other species.

***Trionymus podocarpi* sp. nov.**

Adult female elongate-ovate, dark-red. Antenna of eight joints, last joint longest, formula: 8,3,2,1(5,7)4,6. Rostrum normal, mentum as broad as long. Legs normal, stout, tibia twice length of tarsus; micropores on hind tibia only observed. With only one definite pair of cerarii, each with two long narrow spines and a few loosely-clustered pores. Large tubular ducts present, about five on each side of body, in old specimens they appear to open within a slightly chitinized area; small tubular ducts present, fairly numerous at abdomen. Derm pores of two types: small triangular, widely spaced, and large disc in about three narrow transverse bands at abdomen. Derm setae present, long and fine, in bands at abdomen. Length about 2.20 mm.; width about 1.34 mm.

Hab.—On *Podocarpus dacridioides*, Motueka, Palmerston North.

Type slides in own collection, No. 135.

A very distinct species, and the only one so far reported from the above-mentioned habitat. The elongated ovisac is very prominent, and sometimes averages about half an inch in length. The insect is usually hard to find, owing to the habit of dropping off as soon as the ovisac is completed. Mr E. E. Green (1929) first mentioned this species when reporting on some Coccidae collected by Dr. J. G. Myers, but was not able to name it as the specimens were too much damaged for description.

***Trionymus ambiguus* Morrison.**

1925. *Pseudococcus ambiguus* Morr., *Jour. Agric. Res.*, vol. xxxi, No. 5 (Sept.).

Adult female elongate-ovate, covered with a thin grey meal, with four long pencils of secretion at abdominal extremity and two short ones on frons between antennae. Antenna of eight joints, last joint longest, formula: 8(2,3)1(4,5)6,7 or 8(2,3)4(1,5)6,7. Rostrum normal, mentum longer than broad. Legs normal, stout, tibia about three times length of tarsus; an elongated group of micropores on hind tibia observed. With five definite pairs of cerarii, four of which are on abdomen and one on frons between antennae: ultimate pair each with four stout spines, a very close circular cluster of pores, and about two accessory setae; penultimate pair each with three stout and three to five smaller spines, a very close circular cluster of pores, and about two accessory setae; remaining cerarii on abdomen with two or three small spines and a few clustered pores; cerarii on frons each with three small spines and a large close cluster of pores. Derm pores of two types: small triangular, evenly spaced, and large disc in about four transverse segmental bands on abdomen. Large tubular ducts not observed; small tubular ducts present in about four transverse segmental bands on abdomen, the bands widening as

they approach the margin of the body. Derm setae present, short and fine at abdomen, long and stout at cephalic extremity. Length about 3.94 mm.; width about 1.92 mm.

Hab.—On *Coprosma* sp., *Fagus* sp., *Leptospermum* sp., Motueka.

A very distinct though variable species that cannot be mistaken when prepared for microscopical examination for any other endemic species, owing to the very distinctive cerarii. Morrison first came across this species when examining the Maskell Collection, where it was included as a pinned specimen among the unmounted material of *Pseudococcus calceolariae*.

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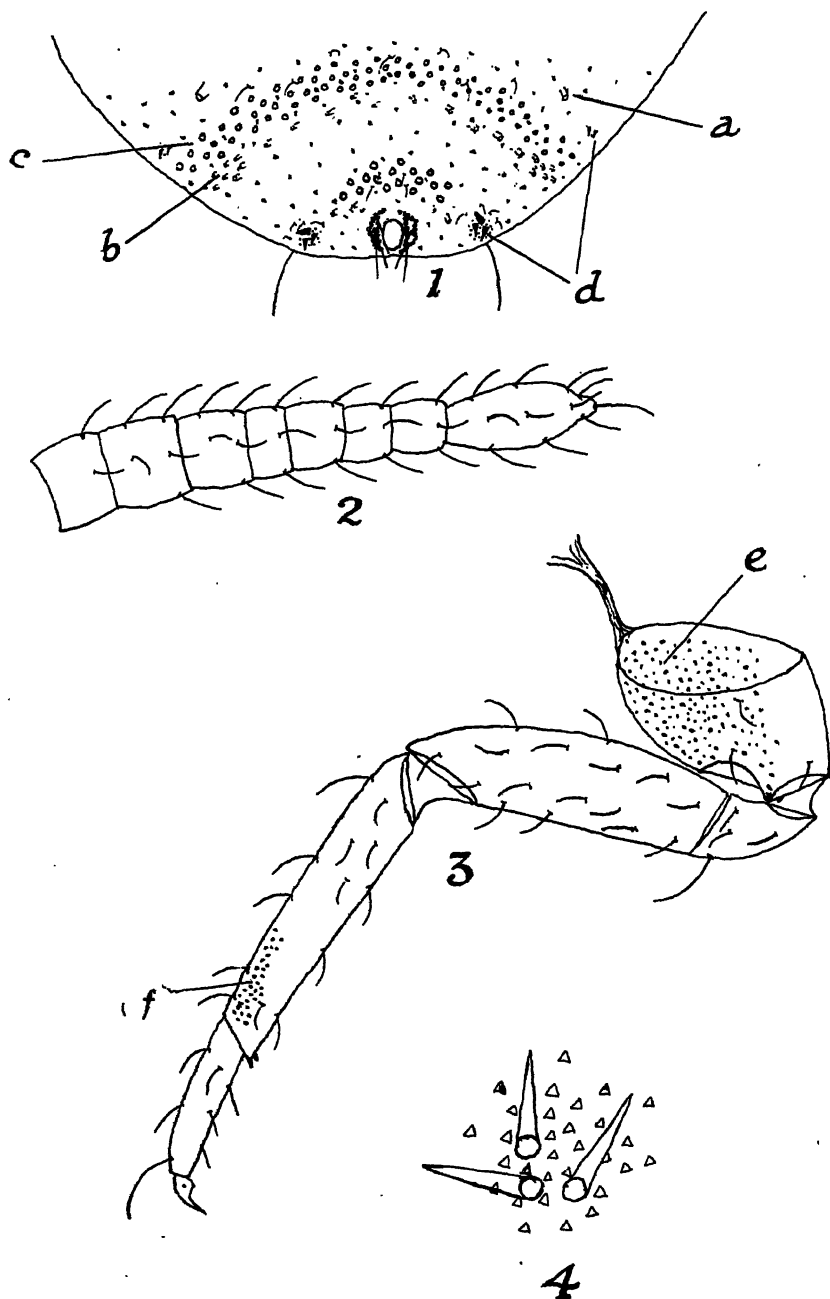


FIG. 1. Margin of pygidium of *Trionymus coriariae*. (a) Large tubular duct. (b) Small tubular ducts. (c) Large disc pores. (d) Cerarii.

FIG. 2. Antenna.

FIG. 3. Hind leg with (e) pores on coxa; (f) pores on tibia.

FIG. 4. Ultimate cerarius showing details.

To face page 348.

A New Genus of Collembola in New Zealand and the Genus *Lepidosira*.

By J. T. SALMON, M.Sc., Entomologist, Dominion Museum.

[*Read before the Wellington Philosophical Society, April 27, 1938; received by the Editor, April 30, 1938; issued separately, December, 1938.*]

THE genus *Lepidosira* Schott contains six species, five of which were described by Schott from Australia (4) and Sarawak (1), and the sixth from New Zealand described by Womersley. The present paper adds seven more species to the genus, all from New Zealand, and introduces a new genus *Urewera* related to *Lepidosira* and containing, so far, five species and three sub-species new to science.

In studying the *Lepidosira*-like Collembola of New Zealand it quickly became evident that there existed a number of forms which could not be definitely placed in that genus; and it is to receive these that I now propose the new genus *Urewera*.

COLLEMBOLA—ARTHROPLEONA.

Family ENTOMOBRYIDAE Börner.

Sub-family ENTOMOBRYINAE Börner.

Tribe ENTOMOBRYINI Börner.

Genus UREWERA nov.

Genotype *Urewera fuchsiata* n.sp., slide 3/82 Dominion Museum Collection.

This genus is characterised by the development of what can only be described as two accessory claws to the foot. These structures are not pseudonychia, but small accessory or secondary claws, each arising independently from the base of the foot above the base of the claw, one on each side, on all feet. In position they are more dorso-lateral than lateral, passing downwards along the sides of the claw, generally with a gentle outward curve, and reaching to from one-quarter to almost one-half of the length of the claw. (Plate 35, figs. 2 and 3). These structures in *Urewera* must not be confused with the wing-like teeth of *Pseudosinella*, from which they are distinct. Specimens of *Urewera* do occur, however, in which the accessory claws curve inwards across the inner margin of the claw, giving it the appearance of a *Pseudosinella*. In describing *P. magna* in *Trans. Roy. Soc. of N.Z.*, vol. 67, p. 355, I now find that I made this error in observation and that this species must now be washed out and incorporated in the genus *Urewera* (spec. *tridentifera*). There always is a single tenent hair, distally clubbed, to each foot. The scales of *Urewera* generally are lightly pigmented, oval in shape, and always heavily and prominently striated, the striations appearing as rows of short dark lines. On closer examination these striations can be seen to be

rows of short thick spines projecting from the surface of the scale at a very low angle. On scales in the posterior region of the body the spines often are longer and project at a greater angle. They give the edges of the scale a broken or "feathered" appearance.

KEY TO THE SPECIES OF UREWERA.

Claws of feet with five teeth	<i>U. fuchsiata</i> sp. nov.
Claws of feet with four teeth, empodial appendage not reaching distal tooth:—	
(a) Ground colour ochreous-brown	<i>U. tridentifera</i> sp. nov.
(b) Ground colour bright yellow	<i>U. flava</i> sp. nov.
(c) Ground colour diffused with pale violet ..	<i>U. tridentifera violacea</i>
(d) Ground colour orange-brown, body suffused with irregular dark pigment patches ..	sub-spec. nov.
Apical tooth sometimes missing, empodial appendage reaching distal tooth	<i>U. tridentifera lichenata</i>
	sub-spec. nov.
Claw with two teeth:—	
(a) Body purple coloured	<i>U. inconstans</i> sp. nov.
(b) Body ochreous with purple bands	
	<i>U. purpurea</i> sp. nov.
	<i>U. purpurea reducta</i>
	sub-spec. nov.

Urewera fuchsiata sp. nov.

Length of body: 2.5–4 mm.

Colour: In life, pale olive-green to dark green, with darker bluish-green markings. Mounted specimens show a body colour of pale yellowish cream, with the intersegmental margins marked by bands of blue. Patches of blue and greenish pigment occur irregularly over the body, particularly on Abd. IV. The legs and antennae are pale ochreous with bands of dark blue, especially on the legs. Scales greenish-brown, prominently striated.

Body: More or less evenly clothed with scales and occasional setae. Prominent tufts of setae occur on the head, apex of mesotergum, and in the posterior region of abdomen. Many of these are strongly ciliated, especially those surrounding the tip of the abdomen; while those at the apex of the mesotergum are bent over at their tips and ciliated on the outer flattened portion. This latter type of setae I find quite often on Collembola; and I propose the term *flexed* setae for use henceforth in describing them. Head diagonal somewhat longer than mesothorax. Antennae four-segmented, the segments related as 15:30:26:34.; slightly longer than half the body, thickly clothed with hair and occasional long setae. The first three antennal segments scaled, these scales long, narrow, and pointed at apex. Ocelli, eight to each side, situated on dark pigment patches joined by a dark frontal line, often incomplete. No post-antennal organ. Anterior pair of eyes very large, four of the remainder medium, and two small. Ventral tube short and invested at its tip with a number of long, curved ciliated setae. Abdomen IV 3–3½ times longer than Abd. III.

Legs: Scaled and bearing numerous long setae, the claw grooved on inner margin with two basal inner teeth about one-third from base, two distal inner teeth at a little over two-thirds, and a single apical tooth a little past halfway between distal pair and apex.

Paired teeth arranged one on each side of claw groove. Two long, prominent outer accessory claws reaching to level of first pair of teeth. Empodial appendage about two-thirds length of claw, lanceolate. Tenent hair almost as long as claw.

Furcula: Reaching to ventral tube, thickly clothed with long setae, many of which are ciliated. Dentes slightly longer than manubrium, corrugated, and annulated; scales dorsal only, long and narrow, and easily rubbed off. Mucrones bidentate with a single external basal spine.

Localities: From under the bark of native fuchsia trees, Waihi Gorge, Urewera Country, and under stones, Waimana Gorge, Bay of Plenty, 1937.

Type: Slide 3/82, Dominion Museum Collection.

***Urewera tridentifera* sp. nov.**

Length of body: 2.8–4 mm.

Colour: This is the most variable species of the genus, two distinct colour forms besides the type being distinctly recognisable. In the typical form, in mounted specimens the basal body colour is pale ochreous with areas of deep violet to purple pigment, as follows: Across front and along sides of head, along ventral edges of thoracic pleura and Abd. I; across anterior and posterior portions of mesothorax, across and slightly down the sides of the posterior halves of metathorax and abdominal segments I and II, and extending right down the sides of Abdomen III. On the rear and sides of Abd. IV and V. Antennal segments I and II pale brown, III darker brown, IV very dark brown with tinge of violet. Legs dark violet, ochreous at joints. The intensity of the pigmented areas often is accentuated by the clothing of scales which generally is heavier in these areas. In life the insect appears greenish-orange, iridescent, with very dark markings across mesothorax, on sides of Abdomens II and III, and on sides and across rear of Abd. IV. Between Abd. III and rear of Abd. IV there usually shows on dorsal surface a conspicuous triangular area, apex directed posteriorly, of light ochreous colour, bounded by the areas of dark pigment.

Body: More or less completely clothed by pale-brown, oval-shaped scales, heavily striated. A tuft of flexed setae at the apex of the mesotergum. Occasional long, ciliated setae occur at random over the body; but from Abdomen IV back there are numerous exceedingly long, ciliated setae extending out from the body in all directions. Around tip of abdomen there often are a number of shorter plumose setae, though these may be entirely absent in many specimens. In all probability they are a sexual adornment. There is a long, thin, sensory, finely-ciliated setae rising vertically from dorsal surface of Abdomen II, and several longer similar setae from rear portion of Abdomen IV. Tergum of mesothorax completely covers prothorax. Head double the length of the metathorax. Ocelli as in *fuchsiata*, eight on each side, six large and two small, situated in dark pigment patches. No post-antennal organ. Antennae four-segmented, scaled on first three segments, with long, narrow, apically-pointed scales,

thickly clothed with ciliated hairs and occasional long setae. Segments related as 18:36:34:34. Ventral tube long and invested with several long, curved, ciliated setae. Abdomen IV $3\frac{1}{2}$ –4 times longer than Abd. III.

Legs: Scaled, with long, narrow, apically-pointed scales, and bearing many ciliated setae. Claw grooved on inner margin, from base to proximal paired teeth, thereafter fading out. Proximal paired teeth situated about one-quarter down from claw base, and very close together, so that often it is difficult to detect that they are paired. A distal tooth occurs at about three-quarters of the way down from the claw base and a third smaller apical tooth about midway between the distal tooth and the apex of the claw, accessory claws reaching to one-third of the length of the claw. Empodial appendage lanceolate, approximately half the length of the claw, never reaching down as far as the distal tooth. Tenent hair about equal to the claw in length.

Furcula: Reaching forward to ventral tube. Thickly clothed with ciliated setae which towards tip of dens become very long, over-reaching the mucro. Mucrodens a little longer than manubrium. Dentes scaled, with long, narrow, apically-pointed scales; corrugated and annulated. Mucro somewhat long, bidentate, with a single basal spine.

Localities: This species is particularly common under the bark of old trees and fallen, decaying branches and logs in all native bush, in association with lichen on trees (sub-spec. *lichenata*) and also is found in decaying leaves and debris on the forest floor or in the forks of trees, throughout Urewera Country up to altitudes of about 2500 ft., and in the Akatarawa Valley and Divide. It seems to be the commonest bark species so far discovered. From about 2500 ft. and above it appears to be displaced by *Urewera flava* n.sp.

Type: Slide 3/96, Dominion Museum Collection.

***Urewera tridentifera lichenata* sub-sp. nov.**

This is a distinct form found generally in association with lichens on tree trunks, in which there is, in addition, a suffusion of more or less irregular small black pigment patches all over the body. In life this form appears orange-brown, with very dark brown markings.

Type: Slide 3/86, Dominion Museum Collection.

***Urewera tridentifera violacea* sub-sp. nov.**

This is another distinct form in which the body is *completely* diffused with pale-violet or purple pigment, except for the head, where a tendency to pale ochreous may still persist. The areas of pigmentation occurring in the type are picked out in this variety as areas of deeper violet or purplish pigmentation. In life these forms appear as dark greenish-brown with darker markings, sometimes approaching to an almost complete iridescent bluish-black.

Type: Slide 3/92, Dominion Museum Collection.

***Urewera flava* sp. nov.**

Length of body: 2.5–2.75 mm.

Colour: Typically bright yellow, with or without markings as in *U. tridentifera*. Markings when present are brown or violet-brown in colour. Readily recognised in life by the predominant bright yellow or sometimes yellowish-green body colour. Legs brown, yellowish at the joints, tarsi bluish. Antennae brown, darkening to deeper colour or violet towards apex.

Body: Head approximately equal to mesothorax in length. Ocelli eight on each side, the inner anterior ocellus generally the largest, the anterior pair larger than the remainder, of which four are medium to large and two small. Each group situated on dark pigment patches which surround also the bases of the antennae and unite across the front of the head. No post-antennal organ. Antennae four-segmented in ratio of 11:25:25:27. First three segments scaled. All segments clothed by moderately long setae. Antennae about equal in length to half the body.

Body scales oval and yellow to pale-brown in colour, heavily striated. Scales of legs, antennae and dentes long, narrow and apically-pointed. A prominent tuft of flexed setae at apex of mesothoracic tergum, which latter completely covers the prothorax. Occasional long setae occur over the body, with long, ciliated setae around posterior region as in *U. tridentifera*. Abd. IV four times longer than Abd. III.

Legs: Scaled and clothed with finely-ciliated setae. Claw and empodial appendage as in *U. tridentifera* with proximal paired teeth at about one-third from claw base.

Furcula: Similar to *U. tridentifera*.

Localities: Under bark of beech and rimu trees, Mt. Ngamoko, Lake Waikaremoana, from 2500 ft. to summit, 3640 ft.

Type: Slide 3/100, Dominion Museum Collection.

***Urewera inconstans* sp. nov.**

Length of body: 1.8–2 mm.

Colour: Ochreous brown in mounted specimens, with ventral edges of thoracic pleura and those of Abd. I, II and III deep violet. Abd. III with prominent band of violet extending across and half-way down the sides. Violet pigment along posterior edge of sides of Abd. IV. Sometimes the thorax may be lightly suffused more or less all over with pale violet. Legs mainly bluish, ochreous at joints. Basal two antennal segments brown, terminal two dark blue. Scales of body oval in shape to round, narrower and pointed elsewhere, heavily striated.

Body: Occasional long ciliated setae occur over the body, especially around the posterior region. Shorter ciliated hairs clothe the head and antennae. A tuft of flexed setae at the apex of the mesothoracic tergum, which latter completely covers the prothorax. Long, slender, finely-ciliated, sensory setae arise vertically, one from Abd. II and

one from Abd. III. There is one similar but longer seta arising dorsally, and one on each side of, Abd. IV. A tuft of long, ciliated setae on each side of posterior extremity of ventral groove. There is a row of short spines across the posterior margin of the head. Antennae a little more than one-third the length of the body, four segmented, the first two segments scaled, the four related in length as 6:11:8:13. Ocelli eight to each side, six large and two smaller. Head diagonal almost equal to thorax in length. Abdomen IV from 4 to 4½ times longer than Abd. III. Ventral tube long.

Legs: Scaled and clothed with hairs and long setae. Claw with inner groove reaching to proximal tooth at about one-third from claw base. Proximal teeth paired, the pair being difficult to detect as the teeth are very closely adpressed laterally. A single distal tooth at about two-thirds and generally, but not always, a third smaller tooth about one-third back from the apex of the claw the distance from the apex to the first and larger distal tooth. The empodial appendage long, narrow, and lance-like, reaching as far as or just past the first distal tooth. Tenent hair about equal to the claw in length.

Furcula: Clothed by ciliated setae which are very long towards tip of dentes and considerably over-reach the mucrones. Manubrium and mucrodens related as 6:7. Dentes heavily scaled, annulated, and corrugated. Mucrones bidentate, the sub-terminal tooth large, and with a basal spine.

Localities: In leaf mould, Waihui Gorge; on shores of Lake Waikaremoana; on top of Huiarau Range, 3200 ft., Urewera Country; and at Akatarawa, 1937. Also found under bark near Lake Waikareiti; in Hopuruahine Gorge; and on Mt. Ngamoko, 3600 ft., Urewera Country, 1937.

Type: Slide 3/107, Dominion Museum Collection.

Urewera purpurea sp. nov.

Length of body: 1.9–2.4 mm.

Colour: In life pale purple to pale greyish-purple. In mounted specimens the head, thorax, and abdominal segments I, II, and III are wholly purple in colour. The anterior portion of Abd. IV is paler in colour or the ground colour of the body may show through as pale ochreous. The posterior portion of Abd. IV, Abd. V, and Abd. VI deeply pigmented with purple. The dorsal surface of the head generally is paler in colour than the sides. Antennae purple, changing to deep violet in segments III and IV. Legs purple, with deep-violet tarsi. Furcula purple at base, passing into pale ochreous in dentes.

Body: Heavily scaled with pale-purple-coloured scales, heavily striated. A group of flexed setae at apex of mesothorax. A number of finely-ciliated long setae around tip of abdomen. A single very fine sensory seta arises vertically from Abd. II. The head is clothed by short ciliated setae in addition to scales. There is a row of short spines across the posterior dorsal margin of the head. Ocelli, eight to each side, six large and two small. Antennae four-segmented, first two segments only with long, narrow, pointed scales, and ciliated

setae. Third segment with plain setae and terminal segment clothed with short, fine hairs. Head approximately equal to thorax in length. Antennae less than half the body in length, the segments related as 4:10:7:10. Abdomen IV 3–3½ times longer than Abd. III.

Legs: Clothed with ciliated setae and long, narrow, pointed scales. Claw with three teeth on inner margin, the proximal paired and at about one-quarter from base, the distal two-thirds. Secondary claws reaching to proximal tooth. Empodial appendage reaching to distal tooth, narrow and lanceolate. Tenent hair shorter than claw.

Furcula: Clothed by ciliated setae, dentes scaled with long, narrow, apically-pointed scales. A prominent ring of stout setae on manubrium at junction with dens. Manubrium and mucrodens equal. Dentes corrugated and annulated. Mucrones bidentate with basal spine, somewhat elongate and surrounded by ciliated setae.

Localities: In old log, 3000 ft., and among forest debris, 3600 ft., on Mt. Ngamoko; among leaf mould, Waihui Gorge and Aniwanui Arm, Lake Waikaremoana; in leaf mould near Blue Lake, Rotorua, 1937.

Type: Slide 3/143, Dominion Museum Collection.

***Urewera purpurea reducta* sub-sp. nov.**

Specimens occur, constituting a distinct variety, in which the body is ochreous in colour with concentrations of purple pigment along the ventral edges of the terga and toward the posterior region of Abd. IV and on Abd. V. Narrow, very pale bands of purple encircle the anterior portion of each segment. This form I have distinguished as *U. purpurea reducta*.

Type: Slide 3/150, Dominion Museum Collection.

Genus LEPIDOSIRA Schott.

The striations characteristic of *Lepidosira* scales are formed similarly to those of *Urewera* by rows of short projecting spines.

KEY TO THE NEW ZEALAND SPECIES OF LEPIDOSIRA.

A. Distinctly segmented species:—

- | | |
|---|---------------------------|
| Very small, violet-coloured, with one inner tooth to claw | <i>L. minima</i> n.sp. |
| Small, brownish-coloured, with three inner teeth to claw | <i>L. minuta</i> n.sp. |
| Large, blue-coloured, with one pair inner teeth to claw | <i>L. rotorua</i> n.sp. |
| Abdomen with six dorso-lateral pigment spots | <i>L. scamacula</i> n.sp. |
| Claw with three teeth, mucro with strongly recurved sub-apical tooth | <i>L. fuscata</i> Wom. |
| Claw with two teeth, empodial appendage truncate .. | <i>L. okarita</i> n.sp. |
| Claw with two teeth, empodial appendage lamellate and bluntly-pointed on inner margin | <i>L. bidentata</i> n.sp. |

B. Segmentation indistinct, brown species, no teeth to claw *L. indistincta* n.sp.

***Lepidosira minuta* sp. nov.**

Length of body: 1.4-1.6 mm.

Colour: Ochreous brown to dark reddish-brown, with darker purple-brown markings along ventral edges of thoracic pleura. Metathorax, abdominal segments I, II, and III, and from hinder portion of Abd. IV to tip of abdomen more or less dark-purple-brown. Head ochreous, varying to violet anteriorly. Antennae ochreous at base, changing through pale-violet to deep-violet in terminal segment. Legs proximally brown, merging into dark-violet distally. Furcula ochreous.

Body: Scaled with brown, oval or rounded, heavily-striated scales. Flexed setae occur on the head and occasionally on the body, with a prominent tuft at apex of thorax. Groups of long ciliated setae occur around Abd. IV, V, and VI. Head about equal to thorax in length. Ocelli eight to each side, seven large and one small, on dark pigment patches. No post-antennal organ. Antennal segments related as 4:8:7:11. All segments scaled and clothed by moderately long setae, the scales long, narrow, and apically-pointed. Abdomen IV four times as long as Abd. III. Ventral tube long and with two distinct lips.

Legs: Covered with fine clothing hairs and moderately long setae, the majority of which are finely ciliated. Claw with three inner teeth, the larger and proximal tooth about one-third from claw base, the distal about two-thirds, and halfway between this and the apex is a third very small tooth. Empodial appendage reaching almost to the second tooth. A tenent hair to each foot about equal in length to claw.

Furcula: Reaching forward to last pair of legs. Clothed by setae. Manubrium to mucrodens as 17:14, dentes corrugated and annulated, scaled with long, narrow, pointed scales. Mucrones bidentate with a basal spine, surrounded and overreached by long ciliated setae.

Locality: From old log near Lake Waikare-iti, 2300 ft., 1937.

Type: Slide 3/120, Dominion Museum Collection.

***Lepidosira minima* sp. nov.**

Length of body: 0.75 mm.

Colour: Basal body colour in mounted specimens very pale cream, more or less tinged with violet. A heavy violet line along ventral edges of pleura and narrow violet bands around posterior margin of all segments. Abdomen III all violet, and Abdomen IV with broad violet band around the middle. Head violet. Antennae violet deepening towards apex. Legs violet, paler at joints. Furcula pale cream. In life, general colour is pale-violet.

Body: Scales are very scarce, the few present being yellowish-brown and striated. Flexed setae occur on top of head and at apex of mesothorax. Occasional setae occur over the body, and several long, slender setae arise from the posterior portion of Abd. IV and from Abd. V and VI. Antennae almost twice as long as head

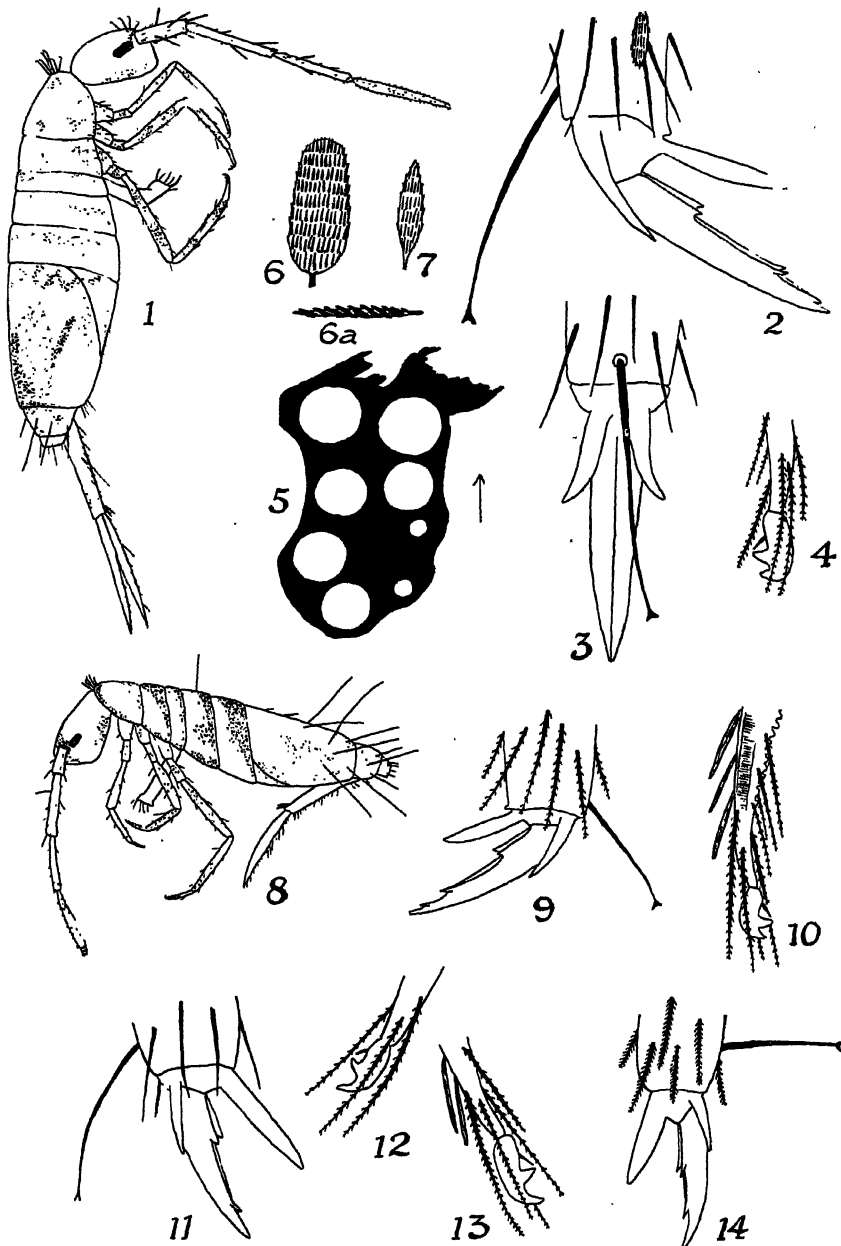


FIG. 1.—*Urewera fuchsiata* sp.nov.: Whole insect. FIG. 2.—*Urewera fuchsiata* sp.nov.: Foot. FIG. 3.—*Urewera fuchsiata* sp.nov.: Foot, showing accessory claws. FIG. 4.—*Urewera fuchsiata* sp.nov.: Mucro. FIG. 5.—*Urewera fuchsiata* sp.nov.: Ocellar group. FIG. 6.—*Urewera fuchsiata* sp.nov.: Scale from body. FIG. 6a.—*Urewera fuchsiata* sp.nov.: Scale from body, side view. FIG. 7.—*Urewera fuchsiata* sp.nov.: Scale from antenna. FIG. 8.—*Urewera tridentifera* sp.nov.: Whole insect. FIG. 9.—*Urewera tridentifera* sp.nov.: Foot. FIG. 10.—*Urewera tridentifera* sp.nov.: Tip of dens and mucro. FIG. 11.—*Urewera inconstans* sp.nov.: Foot. FIG. 12.—*Urewera inconstans* sp.nov.: Mucro. FIG. 13.—*Urewera purpurea* sp.nov.: Mucro. FIG. 14.—*Urewera purpurea* sp.nov.: Foot.

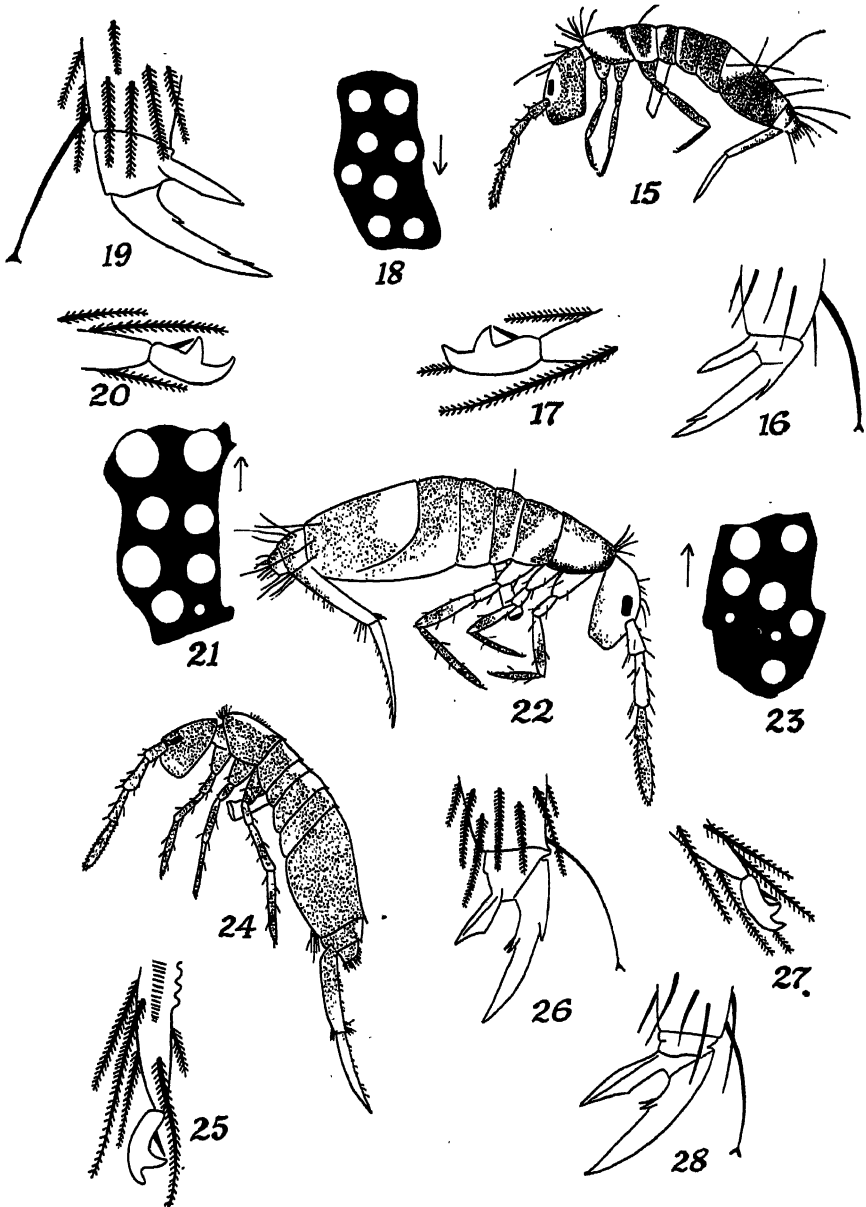


FIG. 15.—*Lepidosira minima* sp.nov.: Whole insect. FIG. 16.—*Lepidosira minima* sp.nov.: Foot. FIG. 17.—*Lepidosira minima* sp.nov.: Mucro. FIG. 18.—*Lepidosira minima* sp.nov.: Ocellar group. FIG. 19.—*Lepidosira minuta* sp.nov.: Foot. FIG. 20.—*Lepidosira minuta* sp.nov.: Mucro. FIG. 21.—*Lepidosira minuta* sp.nov.: Ocellar group. FIG. 22.—*Lepidosira minuta* sp.nov.: Whole insect. FIG. 23.—*Lepidosira rotorua* sp.nov.: Ocellar group. FIG. 24.—*Lepidosira rotorua* sp.nov.: Whole insect. FIG. 25.—*Lepidosira rotorua* sp.nov.: Tip of dens and mucro. FIG. 26.—*Lepidosira rotorua* sp.nov.: Foot. FIG. 27.—*Lepidosira rotorua* sp.nov.: Mucro. FIG. 28.—*Lepidosira bidentata* sp.nov.: Foot.

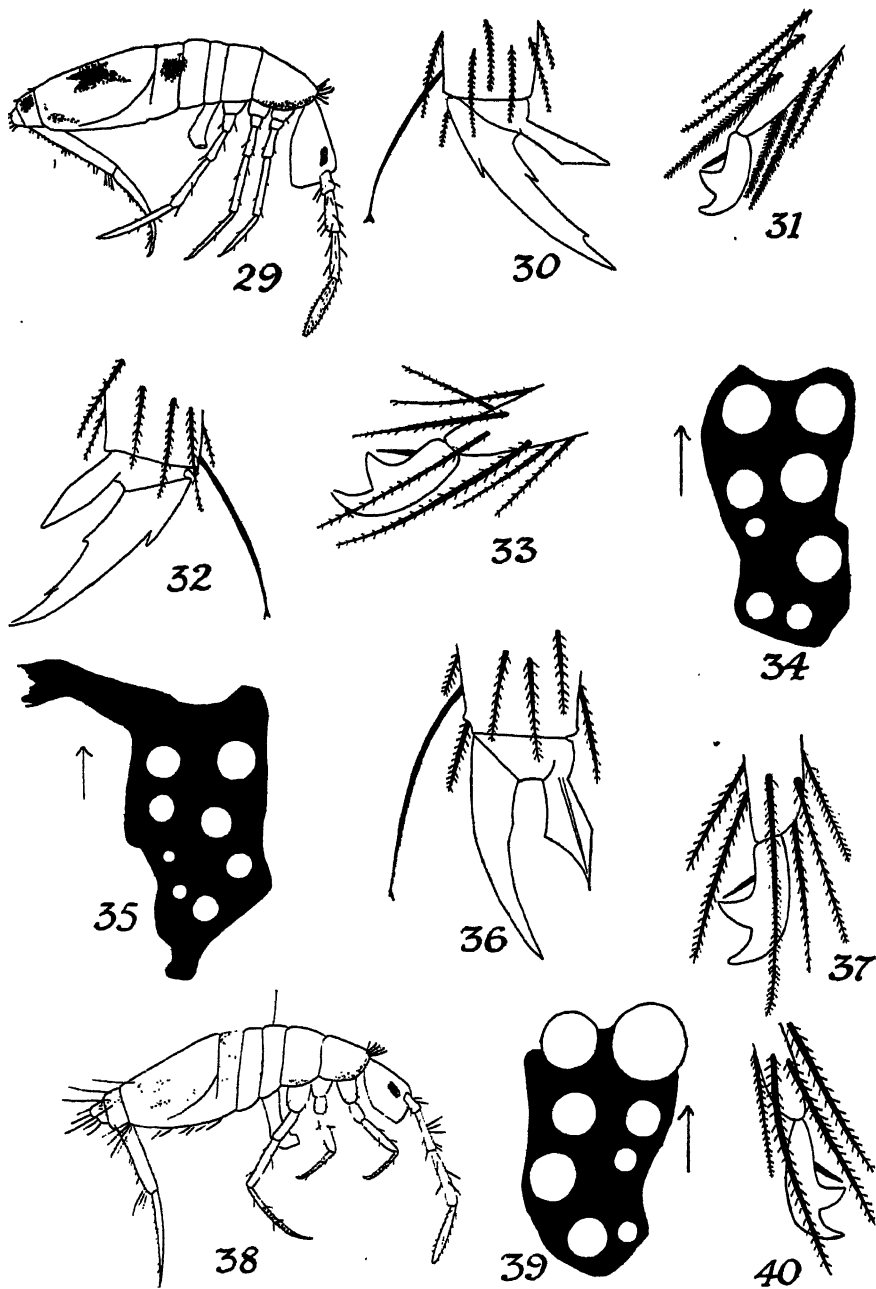


FIG. 29.—*Lepidosira sermacula* sp.nov.: Whole insect. FIG. 30.—*Lepidosira sermacula* sp.nov.: Foot. FIG. 31.—*Lepidosira sermacula* sp.nov.: Mucro. FIG. 32.—*Lepidosira okarita* sp.nov.: Foot. FIG. 33.—*Lepidosira okarita* sp.nov.: Mucro. FIG. 34.—*Lepidosira okarita* sp.nov.: Ocellar group. FIG. 35.—*Lepidosira indistincta* sp.nov.: Ocellar group. FIG. 36.—*Lepidosira indistincta* sp.nov.: Foot. FIG. 37.—*Lepidosira indistincta* sp.nov.: Mucro. FIG. 38.—*Urewera flava* sp.nov.: Whole insect. FIG. 39.—*Urewera flava* sp.nov.: Ocellar group. FIG. 40.—*Urewera flava* sp.nov.: Mucro.

diagonal, clothed by short setae, the segments related as 3:6:6:8. Ocelli eight to each side, all large, on dark pigment patches. Abdomen IV three times as long as Abdomen III.

Legs: Clothed by moderately long setae, claw with single external basal tooth and one inner tooth near the apex. Empodial appendage a little longer than half the claw. A single tenent hair, almost as long as the claw, to each foot.

Furcula: Reaching forward to ventral tube. Manubrium to mucrodens as 11:13. Dentes annulated and corrugated, scaled lightly with long, thin scales difficult to detect. Furcula clothed with setae, which around mucrones are long and ciliated. Mucrones bidentate with basal spine, the terminal tooth shorter.

Locality: In leaf mould, Akatarawa, 1937.

Type: Slide 3/146, Dominion Museum Collection.

Lepidosira rotorua sp. nov.

Length of body: 2.8–3 mm.

Colour: In life a beautiful deep blue. In mounted specimens body and appendages all a deep blue. There is a tendency for a trace of yellowness along the dorsal surface of the thorax, and abdominal segments I, II, III, and V.

Body: Lightly scaled, with brownish scales strongly striated, a tuft of stiff setae at apex of mesothorax, and occasional similar setae over body. Short, stiff, ciliated setae around tip of abdomen. Tufts of long ciliated setae at ventral posterior edge on each side of ventral groove. Head slightly longer than mesothorax. Antennae scaled on first three segments and heavily clothed with short, finely-ciliated setae. Segments related as 9:14:12:20. Ocelli eight to each side, six large, two small, on dark pigment patches. No post-antennal organ. Terga of mesothorax completely covers prothorax. Mesothorax considerably longer than metathorax as 19:10. Ventral tube short and stout. Abdomen IV five times longer than Abdomen III.

Legs: Scaled and clothed by long and short ciliated setae. Claw with paired inner teeth at about one-third from base and small external tooth. Empodial appendage about two-thirds length of claw; lamellate, truncate on inner margin and finely pointed. A single tenent hair to each foot slightly less than the claw in length.

Furcula: Reaching forward to ventral tube. Clothed with setae. Manubrium to mucrodens as 28:32. Dentes scaled by small elongate lancet-shaped scales. Mucrones bidentate, with a single basal spine. Apical tooth smaller and blunt. Mucrones surrounded by long ciliated setae.

Locality: From amongst dead leaves in bush on shores of Blue Lake, Rotorua, 1937.

Type: Slide 3/128, Dominion Museum Collection.

***Lepidosira bidentata* sp. nov.**

Length of body: 2-3.25 mm.

Colour: Yellowish-brown, with deep-blue to violet patches on the sides and ventral surface of the head and body segments. Legs mainly bluish, but with femurs brown. Antennae deep-blue with joints pale-brown.

Body: Scaled with brown, heavily-striated scales. A tuft of stout setae occurs at apex of thorax, and strongly ciliated long setae arise around posterior region of abdomen. Antennae slightly less than half the length of the body, thickly clothed with short setae, but no scales, the segments related as 12:23:20:34. Ocelli eight to each side, all large, on dark-blue pigment patches joined by a line of dark-blue pigment across front of head. No post-antennal organ. Tergum of mesothorax completely covers prothorax. Abdomen IV five times as long as Abdomen III. Ventral tube long.

Legs: Claw with one pair of large basal inner teeth, at about one-quarter from base. Empodial appendage broadly lamellate, bluntly pointed on inner margin and sharply-pointed apically. Single tenent hair to each foot about equal to claw in length.

Furcula: Reaching forward to mesothorax. Manubrium slightly shorter than mucrodens. Dentes heavily clothed by ciliated setae, many of which at the tips overreach the mucrones, annulated and corrugated, and scaled with long lancet-like scales. Mucrones bidentate, with single basal spine. Subterminal tooth very large.

Locality: In forest debris, Aniwaniwa Arm, Lake Waikaremoana, 1937.

Type: Slide 3/125, Dominion Museum Collection.

***Lepidosira sexmacula* sp. nov.**

Length of body: 2.25 mm.

Colour: Pale yellow ochreous with a trace of blue pigment along ventral edge of mesothorax. There are three prominent patches of blue pigment on each side of the abdomen, one on Abd. III, one in centre of Abd. IV, and one on Abd. V. There is also a small patch of blue pigment on posterior ventral region of Abd. IV. Antennae pale brown, darker at joints, and shading to violet in third and terminal segments. Legs and furcula pale ochreous.

Body: Sparsely scaled, scales pale brown, striated, and oval in shape. A tuft of short setae at apex of thorax. A few short ciliated setae around tip of abdomen. Body otherwise mainly bare. Head slightly longer than mesothorax. Ocelli eight on each side, six large and two small. No post-antennal organ. Antennae four-segmented, the segments related as 6:10:10:15. Retractable organ at apex. Mesothorax completely covers prothorax and is related to metathorax as 15:9. Abdomen IV five times longer than Abdomen III.

Legs: Clothed with short ciliated setae and sparsely by lancet-like scales. Claw with two outer basal teeth, one to each side, and two prominent inner teeth, one at about one-quarter and the other at three-quarters down the claw. Empodial appendage about two-thirds the length of the claw and slightly truncate on inner margin. A single tenent hair to each foot somewhat shorter than the claw.

Furcula: Reaching forward to anterior pair of legs. Manubrium related to mucrodens as 20:23. Scales of dentes long and narrow, lancet-shaped. Dentes annulated and corrugated and clothed with setae. Mucrones bidentate with basal spine, the apical tooth small. Mucrones surrounded by short ciliated setae.

Locality: In bush debris on forest floor, Okarita Lake, Rotorua, 1937. A single specimen only obtained.

Type: Slide 3/119, Dominion Museum Collection.

***Lepidosira indistincta* sp. nov.**

Length of body: 2.7 mm.

Colour: A uniform pale ochreous. Legs and furcula ochreous or pale violet. Basal antennal segments ochreous with a violet tinge, segments III and IV deep violet. Ant. II becomes violet towards joint with Ant. III.

Body: Head and trunk heavily clothed with typical pale brown striated scales. Numerous long ciliated setae occur over body, especially on abdominal segments IV, V, and VI. A prominent tuft of flexed setae at apex of mesothorax. Head diagonal, slightly longer than mesothorax. Ocelli eight to each side, one large, five medium, and two small, situated on dark pigment patches joined across front of head by deep violet band, which also skirts bases of antennae. Antennae slightly less than half the body in length; four-segmented, related as 7:12:10:17, scaled on first two segments and well-clothed by setae, many of which are ciliated. Ant. IV bears very short setae only. A row of short spines across posterior dorsal margin of head. No post-antennal organ. Segmentation very indistinct. Abd. IV about three times longer than Abd. III.

Legs: Not scaled, but clothed thickly with short, heavily-ciliated setae. Claw without any properly-defined teeth, but a slight irregularity like a rudimentary tooth about one-quarter from the base. Empodial appendage sharply pointed with a distinct inner and outer lamella and "mid-rib." A single tenent hair to each foot about equal in length to the claw.

Furcula: Thickly clothed with setae, many of which are ciliated. Dentes only feebly corrugated and annulated. Scales lancet-like. Mucro-bidentate with basal spine, somewhat long and parallel-sided, surrounded by long, ciliated setae.

Locality: Waioeka Valley, Urewera Country, from old rotten tree stump, 2000 ft., 1937.

Type: Slide 3/147, Dominion Museum Collection.

Lepidosira okarita sp. nov.

Length of body: 2.1 mm.

Colour: In life, ginger-brown. Mounted specimen shows basal body colour of pale ochreous with bright orange-brown pigment on front of head, along anterior ventral edge of mesothorax, and on basal segments of legs. Antennal segments I and II pale brown, III and IV shading to pale violet, becoming deeper towards apex. Legs mainly ochreous, becoming violet on tarsi. Body colour becomes darker or lighter as clothing of scales is heavy or light.

Body: Heavily clothed with scales, of which there are two types: (1) Pale coffee-coloured, heavily striated, and either oval or almost round in shape. On the head and thorax they are mostly oval, on the remainder of the body almost entirely round. Some of these scales are very large, round ones measuring as much as .06 mm. in diameter, and oval ones up to .13 mm. long. Basally, the scale-colour is very pale, becoming stronger at about one-third from the base of the scale. (2) Bright yellow scales, which are very transparent and lightly striated, either round or oval in shape, many of them quite large. They occur mainly as bands between the segments, principally between abdominal segments II and III and III and IV. A few isolated yellow scales occur on Abd. IV. On the antennae, legs, and furcula, particularly on the dentes, the scales become long, narrow, and apically-pointed, rather lancet-like in shape. Head slightly longer than mesothorax. Ocelli eight to each side, five large, three small, on dark pigment patches. Antennae scaled and clothed with short, ciliated setae with occasional longer setae on second segment. Retractable organ at apex. Segments related as 7:19:15:18. Numerous short ciliated setae occur over the surface of the head. A row of short spines across the posterior dorsal margin of the head. Numerous fine ciliated setae fringe the ventral edge of the thoracic pleura and on abdominal segments III and IV. There is a very long and thin vertical sensory setae on Abdomen II. Abdominal segment IV four times longer than Abdomen III. Ventral tube short and yellow in colour.

Legs: Scaled and clothed with ciliated setae. Claw grooved on inner margin, with paired proximal inner teeth at about one-third from base and single distal tooth at about two-thirds. A single basal external tooth. Empodial appendage lanceolate and reaching to distal tooth. A single spur hair, not distally-clubbed, to each foot.

Furcula: Reaching to ventral tube, scaled and clothed with ciliated setae. Manubrium to mucrodens as 33:38. Dentes annulated and corrugated. Mucrones bidentate with basal spine, the apical tooth the smaller. Strongly ciliated setae overreach the mucrones.

Localities: In leaf mould, under tree-ferns on shore of Okarita Lake, Rotorua; in leaf mould, Mamaku Hill, Rotorua, 1937.

Type: Slide 3/117, Dominion Museum Collection.

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Tertiary Molluscan Faunules from the Waitemata Beds.

By A. W. B. POWELL, Auckland Museum.

[Read before the Auckland Institute, April 18, 1938; received by the Editor, May 5, 1938; issued separately, December, 1938.]

SINCE the first paper on the Waitemata Beds (Powell and Bartrum, 1929, *Transactions of the New Zealand Institute*, vol. 60, pp. 395-447) I had the good fortune to locate at Squadron or "Church" Bay, Waiheke Island, almost a replica of the original Oneroa bed. The new locality is about one mile to the south-west across the island from Oneroa and on the western coast. Apparently some short time prior to my discovery of the new bed a series of strong gales caused a landslide which exposed a large face of fossiliferous mudstone cliff. The removal of the debris and accumulated shingle by the same agency laid bare also for a time a tidal area of mudstone about 80 yards long by 30 to 40 yards wide which was very rich in fossils. Underlying this zone and exposed at the extremities of the platform is a coarse conglomerate composed of greywacke debris from the undermass, and this proved rich in derived fossils including *Parapholas* (genus new to New Zealand) and many opercula of "*Turbo*" *superbus*.

As will be seen from the combined list for the two localities, many of the species are common to both beds. A number of new species from these localities form the subject of this paper, as well as novelties from two other Waitemata basal beds—Motuihi Island, west side (not previously recorded) and east side of Bostaquet Bay, Kawan Island (locality described by Ferrar, *N.Z. Geol. Surv. Bull.*, No. 34, New Series, p. 37).

To return to the Squadron Bay bed, it was found that the most abundant species were *Eucrassatella ampla*, *Dosinia bensoni*, *Cardium greyi*, *Maoricolpus gittosina*, *M. waitemataensis* and *Polinices oneroaensis*, all except the latter being more abundantly represented at Squadron Bay than in the bed near Oneroa. The further material indicates no reconsideration in respect to the assumed age of these basal Waitemata beds, which in 1929 (p. 396) were considered by Powell and Bartrum to belong to the Hutchinsonian Stage of the Upper Oligocene.

MOLLUSCA FROM TERTIARY BEDS AT WAIHEKE ISLAND, AUCKLAND.

- A: Original bed near Oneroa (described by Powell and Bartrum, 1929).
 B: Oneroa Beach (rarely free from sand).
 C: Newly discovered bed at Squadron Bay.
 *: New records.

Class PELECYPODA.

<i>Nucula</i> cf. <i>nitidula</i> A. Adams, 1856	..	..	..	A
<i>Anomia trigonopsis</i> Hutton, 1877	..	..	..	A & C
<i>Navicula waitemataensis</i> Powell and Bartrum, 1929	..	..	..	A
* <i>Glycymeris</i> (<i>Grandaxinea</i>) <i>aucklandica</i> n.sp.	..	..	..	C

<i>Mytilus tetleyi</i> Powell and Bartrum, 1929	..	..	A
<i>Musculus</i> cf. <i>impactus</i> (Hermann, 1782)	..	..	A
<i>Pteria oneroaensis</i> (Powell and Bartrum, 1929)	..	..	A
* <i>Pedalion</i> n.sp.	..	..	C
* <i>Pedalion</i> n.sp.	..	..	B
<i>Lima</i> sp. (indet.)	..	..	A
<i>Ostrea</i> (<i>Gigantostrea</i>) <i>gittosina</i> Powell and Bartrum, 1929	..	..	A & C
<i>Eucrassatella ampla</i> (Zittel, 1865)	..	..	A & C
* <i>Venericardia</i> (<i>Megacardita</i>) <i>squadronensis</i> n.sp.	..	..	A & C
<i>Venericardia</i> sp. juv. (indet.)	..	..	A
<i>Chama</i> sp. (indet.)	..	..	A
<i>Notomyrtea</i> sp. (indet.)	..	..	A
<i>Melliteryx mirificus</i> Powell and Bartrum, 1929	..	..	A
<i>Maoritellina hesterna</i> Powell and Bartrum, 1929	..	..	A
<i>Angulus robini</i> (Finlay, 1924)	..	..	A
<i>Bartrumia oneroaensis</i> (Powell and Bartrum, 1929)	..	..	A
<i>Leptomya waitemataensis</i> Powell and Bartrum, 1929	..	..	A
<i>Scalpomactra biconveza</i> Powell and Bartrum, 1929	..	..	A & C
<i>Lutraria trapezoidalis</i> Powell and Bartrum, 1929	..	..	A & C
<i>Zenatia acinaces</i> (Q. and G., 1835)	..	..	A & C
<i>Dosinia</i> cf. <i>lambata</i> (Gould, 1850)	..	..	A & C
<i>Dosinia</i> (<i>Raina</i>) <i>bensoni</i> Marwick, 1927	..	..	A & C
<i>Tawera</i> cf. <i>bartrumi</i> Marwick, 1927	..	..	A
* <i>Eumarcia</i> (<i>Atamarcia</i>) <i>curta</i> (Hutton, 1873)	..	..	A
<i>Cardium</i> (<i>Trachycardium</i>) <i>greyi</i> Hutton, 1873	..	..	A & C
* <i>Cardium oneroaensis</i> n.sp.	..	..	C
<i>Gari</i> cf. <i>lineolata</i> (Gray, 1835)	..	..	A
<i>Notocorbula pumila</i> (Hutton, 1885)	..	..	A & C
<i>Notocorbula</i> aff. <i>zelandica</i> (Q. and G., 1835)	..	..	A
<i>Hiatella</i> sp.	..	..	A
<i>Panopea orbita</i> (Hutton)	..	..	A
<i>Bankia turneri</i> Powell and Bartrum, 1929	..	..	A
* <i>Parapholas aucklandica</i> n.sp.	..	..	C

Class GASTEROPODA.

<i>Haliotis</i> sp. (indet.) probably <i>waitemataensis</i> n.sp.	..	..	A
<i>Tugali navicula</i> Finlay, 1926	..	..	A
<i>Modelia</i> aff. <i>granosa</i> (Martyn, 1784)	..	..	A
<i>Sarmaturbo superbus</i> (Zittel, 1864)	..	..	A & C
<i>Cellana thomsoni</i> Powell and Bartrum, 1929	..	..	A
<i>Bembicium priscum</i> Powell and Bartrum, 1929	..	..	A
<i>Estea verticostata</i> Powell and Bartrum, 1929	..	..	A
<i>Notosetia</i> cf. <i>stewartiana</i> (Suter, 1908)	..	..	A
<i>Subonoba</i> aff. <i>fumata</i> (Suter, 1898)	..	..	A
<i>Nozeba candida</i> Finlay, 1924	..	..	A
<i>Zefallacia benesulcata</i> Powell and Bartrum, 1929	..	..	A & C
<i>Pyræzus consobrinus</i> Powell and Bartrum, 1929	..	..	A & C
<i>Pyræzus waitemataensis</i> Powell and Bartrum, 1929	..	..	A & C
<i>Maoricolpus gittosina</i> Powell and Bartrum, 1929	..	..	A & C
<i>Maoricolpus waitemataensis</i> Powell and Bartrum, 1929	..	..	A & C
<i>Zeacolpus tetleyi</i> Powell and Bartrum, 1929	..	..	A
<i>Struthiolaria lawsei</i> Powell and Bartrum, 1929	..	..	A & C

<i>Zegalerus peramplus</i> Powell and Bartrum, 1929 ..	..	A
<i>Sigapatella patulosa</i> Powell and Bartrum, 1929 ..	..	A
<i>Sigapatella subvaricosa</i> Powell and Bartrum, 1929 ..	..	A
<i>Maoricrypta</i> aff. <i>opuraensis</i> Bartrum and Powell, 1928 ..	..	A
<i>Maoricrypta</i> aff. <i>costata</i> (Sowerby, 1824) ..	..	A
<i>Polinices oneroaensis</i> Powell and Bartrum, 1929 ..	..	A & C
* <i>Magnatica</i> (<i>Spelaenacca</i>) <i>waitemataensis</i> n.sp. ..	..	C
* <i>Willungia fracta</i> (Tomlin, 1916) ..	..	C
<i>Cabestana tetleyi</i> (Powell and Bartrum, 1929) ..	..	A & C
* <i>Mayena bartrumi</i> n.sp. ..	..	C
<i>Proxicharonia arthritica</i> (Powell and Bartrum, 1929) ..	..	A & C
* <i>Euspinacassis oneroaensis</i> n.sp. ..	..	A
<i>Morum</i> (<i>Oniscidia</i>) <i>harpiformis</i> Powell and Bartrum, 1929 ..	..	A
<i>Pyrgulina</i> cf. <i>pseudorugata</i> Marsh. and Murd., 1921 ..	..	A
<i>Diplomitra waitemataensis</i> Powell and Bartrum, 1921 ..	..	A
<i>Austrosipho</i> (<i>Verconella</i>) <i>exoptatus</i> Powell & Bartrum, 1929 ..	..	A
<i>Buccinulum</i> (<i>Evarnula</i>) <i>tetleyi</i> Powell and Bartrum, 1929 ..	..	A
<i>Austrofusus</i> (<i>Neocola</i>) <i>oneroaensis</i> Powell & Bartrum, 1929 ..	..	A
<i>Cominella</i> (<i>Paracomina</i>) <i>lignaria</i> Powell and Bartrum, 1929 ..	..	A & C
<i>Cominella</i> (<i>Paracomina</i>) <i>finlayi</i> Powell and Bartrum, 1929 ..	..	A & C
<i>Murexsul echinophorus</i> Powell and Bartrum, 1929 ..	..	A
<i>Vesamula waitemataensis</i> (Powell and Bartrum, 1929) ..	..	A
<i>Xymenella asperula</i> (Powell and Bartrum, 1929) ..	..	A
<i>Lepsiella maxima</i> Powell and Bartrum, 1929 ..	..	A & C
<i>Lepsiella intermedia</i> Powell and Bartrum, 1929 ..	..	A
* <i>Hima</i> (<i>Mirua</i>) aff. <i>socialis</i> (Hutton, 1886) ..	..	C
<i>Baryspira platycephala</i> Powell and Bartrum, 1929 ..	..	A & C
* <i>Waihaia</i> n.sp. ..	..	C
<i>Austrotoma finlayi</i> n.sp. ..	..	A & C
<i>Rugobela sepelibilis</i> (Powell and Bartrum, 1929) ..	..	A
<i>Inquisitor</i> cf. <i>awamoensis</i> (Hutton, 1873) ..	..	A
<i>Phenatoma</i> (<i>Cryptomella</i>) <i>transenna</i> (Suter, 1917) ..	..	A
<i>Acteon oneroaensis</i> Powell and Bartrum, 1929 ..	..	A
<i>Cylichnina enucleata</i> Powell and Bartrum, 1929	A

Class AMPHINEURA.

<i>Ischnochiton vetustus</i> Powell and Bartrum, 1929	A
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Class SCAPHOPODA.

<i>Dentalium</i> sp.	A & C
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GLYCYMERIDAE.

Genus GLYCYMERIS Da Costa, 1778.

Type (tautonymy): *Arca glycymeris* Linn.

Subgenus GRANDAXINEA Iredale, 1931.

Type (orig. desig.): *G. magnificoens* Iredale.*Glycymeris* (*Grandaxinea*) *aucklandica* n.sp. (Pl. 38, fig. 9.)

This species shows relationship both to the Recent *laticostata* and the Awamoan (Burnt Hill) *monsadusta* Marwick (1932, *Rec. Cant. Mus.*, vol. 3, p. 496). The Waiheke species resembles *monsadusta* in having inflated beaks and a similar number of radial ribs

(32), but in shape it is nearer to *laticostata*, being proportionately wider than *monsadusta* and with a more broadly arched hinge line. The actual hinge teeth, however, are more massive than in *laticostata*, and the posterior end of the shell is slightly produced, a condition sometimes found in Recent *laticostata*. (Part of the postero-dorsal margin is broken away in the holotype.)

Height, 55 mm.; length, 56 mm.; inflation (one valve), 18 mm.

Locality: Squadron Bay, Waiheke Island, Auckland. Collected by A. W. B. P.

Holotype in Auckland Museum.

PTERIIDAE.

Genus *PTERIA* Scopoli, 1777.

Type (monotypy): *Mytilus hirundo* Linn.

The finding of further material shows that the holotype and paratype respectively of *Isognomon oneroaensis* Powell and Bartrum, 1929, are not the same species. The specimen selected as holotype had the hinge features obliterated, but showed an almost complete outline; the paratype, however, was a hinge fragment showing unmistakable ligamental pits.

It is now clear that the holotype of *Isognomon oneroaensis* is a *Pteria*. As the original description is inadequate, I now provide a description of a well preserved example collected by Mr. C. A. Fleming.

The paratype of *Isognomon oneroaensis* (1929, pl. 44, fig. 69) certainly is an *Isognomon* (= *Pedalion*), but cannot retain the name *oneroaensis* as the holotype of that species proves to be a *Pteria*. This figured paratype may be indicated as *Isognomon* n.sp., the specimen being too fragmentary to name. The position is further complicated by the finding in the same beds of several fragments of another species of *Isognomon* close to the Pliocene *zelandica* Suter.

Pteria oneroaensis (Powell and Bartrum, 1929).

1929. *Isognomon oneroaensis* Powell and Bartrum, *Trans. N.Z. Inst.*, vol. 60, p. 400, pl. 49, f. 106; not pl. 44, f. 69.

Description of neotype (pl. 38, fig. 4):—Shell large, nacreous, trapezoid, moderately and broadly inflated, the greatest inflation occurring medially along an arc extending from the umbo to the middle of the ventral margin. Dorsal margin moderately long (probably much longer than shown in the neotype), straight; umbo low. Anterior auricle rather large, triangular, set off from the rest of the shell by a depression extending from the long, rather narrow, byssal sinus to the front of the umbo. Anterior margin below the auricle almost vertical, posterior margin broadly rounded, steep, barely subangled where it joins the broadly rounded ventral margin. Cardinal area smooth and long, almost the length of the dorsal margin. Hinge teeth under umbo not exposed; the rest of the hinge

is shown to be plain, being exposed from the back by the breaking away of the right valve. Sculpture of weak concentric growth lines only.

Height, 100 mm.; diameter, 97 mm. (neotype).

Neotype in Auckland Museum Collection. Presented by Mr. C. A. Fleming.

Locality: Squadron Bay, Waiheke Island.

The species is much more erect in growth and has a considerably smaller posterior auricular area than in the normal form for the genus. In fact, its strong resemblance in form to *Isognomon* caused the curious error in the earlier paper on the Waiheke beds (Powell and Bartrum, 1929).

CRASSATELLITIDAE.

Genus *EUCRASSATELLA* Iredale, 1924.

Type (orig. desig.): *Crassatella kingicola* Lamarck.

Eucrassatella ampla (Zittel), 1865. (Pl. 38, figs. 1, 2 and 3.)

1865. *Crassatella ampla* Zittel, *Voy. "Novara," Palae.*, p. 46, pl. 14, f. 3 a, b.

1914. *Crassatellites amplus* (Zittel): Suter, *N.Z. Geol. Surv. Pal. Bull.*, no. 2, p. 47, pl. 13, f. 3. (Plesiotype.)

1929. *Eucrassatella attenuata* (Hutt.): Powell and Bartrum, *Trans. N.Z. Inst.*, vol. 60, p. 402, f. 107.

There has been some doubt as to whether Hutton's *attenuata* is distinct from *ampla*, but after examining long series I am convinced that there are two distinct species. Outline is deceptive, for this led Powell and Bartrum, 1929 (*l.c.*) to class a Waiheke shell as *attenuata* whereas on hinge characteristics it is decidedly *ampla*. Quite irrespective of outline, therefore, *ampla* may always be separated from *attenuata* by the more massive and proportionately deep hinge. The following measurements and ratios for a series of each species shows them to be distinguishable. Generally *ampla* is of trigonal outline and *attenuata*, as the name suggests, more elongate sub-trigonal.

ampla:

*Length,	117 mm.;	height,	85 mm.	Ratio hinge to height,	3.2	Waiheke.
"	120	"	100	"	3.3	"
"	121	"	102	"	3.4	"
"	130	"	115	"	3.3	"
"	134	"	108	"	3.3	"
"	95	"	80	"	—	Type

attenuata:

Length,	153 mm.;	height,	116 mm.	Ratio hinge to height,	—	Type
"	91	"	83	3.8	Target	Gully
"	98	"	64	"	4.0	" "
"	113	"	85	"	3.8	" "
"	113	"	83	"	3.6	Clifden 7a "
"	117	"	82	"	3.9	" "
"	119	"	85	"	3.5	Target "Gully
"	122	"	93	"	3.5	" "

* Figured specimen, Powell and Bartrum, 1929, f. 107.

CARDITIDAE.

Genus VENERICARDIA Lamarck, 1801.

Type (subsq. desig., Gray, 1847): *Venus imbricata* Gmel.

Subgenus MEGACARDITA Sacco, 1899.

Type (fide Dall., 1900): *Venericardia jouanneti* Basterot.**Venericardia (Megacardita) squadronensis n.sp.** (Pl. 38, figs. 10, 11 and 12.)

Shell very large, massive, rhomboid; characterised by broad, flattened, radial ribs with linear interstices. Umbo prominent, at anterior fourth. Sculpture consisting of 26 radials, the last nine towards the posterior end being from a third to a half the width of the others, which are broad and flattened as described above. The concentric growth lines are obsolete over most of the shell, weak folds surmounting the radials being present only on the first seven radials from the anterior end. The holotype is imperfect in outline, but is selected as it shows the distinctive ribbing to best advantage; the figured paratype provides the outline of the species. Hinge as in *ponderosa* Suter.

Length, 81 mm.; height, 71 mm.; inflation (one valve), 23 mm. (paratype).

Locality: Squadron Bay, Waiheke Island, Auckland; east side of Bostaquet Bay, Kawau Island. Collected by A. W. B. P.

Holotype in the writer's collection, Auckland Museum: (Squadron Bay). (Pl. 38, fig. 10.)

This species is closely allied to Suter's *ponderosa* (*Trans. N.Z. Inst.*, vol. 45, p. 296) from Muddy Terrace, Waikaia, but differs in the ribs being more flattened and the interstices narrower. These differences are constant at all stages of growth.

CARDIIDAE.

Genus CARDIUM Linné, 1758.

Type (subsequent desig. Gray, 1847): *Cardium costatum* Linné.**Cardium oneroaensis n.sp.** (Pl. 38, figs. 7 and 8.)

Shell large, subcircular, massive, much inflated; umbo at about anterior third, large, incurved, somewhat flattened on top. Sculptured with 41 broad, flattened radial ribs with linear interspaces; and well-developed nodose spines on the ribs towards the lower margin. Hinge massive; left valve with two cardinals joined above, the anterior one the larger, triangular; lower cardinals separated from one another by a large obliquely triangular socket, for the reception of the right valve cardinal. Anterior lateral strong, posterior lateral broken away. Nymph broad and strong.

Height, 93 mm.; length (estimated), 98 mm.; inflation (one valve), 40 mm. (holotype).

Locality: near Oneroa, Waiheke Island.

Holotype in writer's collection, Auckland Museum.

The species belongs to the *spatiosum* series, which includes *strangi* Laws, 1930, and *gudexi* Laws, 1933, as well as *spatiosum* Hutton, 1873.

PHOLADIDAE.

Genus *PARAPHOLAS* Conrad, 1849.Type (monotypy): *Pholas californica* Conrad.*Parapholas aucklandica* n.sp. (Pl. 38, figs. 5 and 6.)

Shell comparatively short, elliptical, anterior end bulbous, then rapidly contracting to the rather sharply pointed anterior end. Anterior end closed by a thin swollen callus, very slightly gaping. There is a single large, broad, anterior accessory plate (protoplax) as shown by the smooth rounded attachment surfaces on the valves. Two other accessory plates (the mesoplax and the metaplax) are double and confluent, and extend from the protoplax to within a short space of the posterior extremity of the shell. These plates are very broad medially and gradually taper behind. Valves divided into three areas by two radial folds, the first shown as a shallow groove and the second as a slight angle. Anterior portion with the upper part decussated by fine radial and concentric sculpture, and the lower part smooth callus; median and posterior portions with close regular concentric folds.

Length, 33 mm.; height, 20.5 mm.; diameter, 19 mm. (holotype).

Locality: Squadron Bay, Waiheke Island. Collected by A.W.B.P.

Holotype in Auckland Museum. (Pl. 38, fig. 5.)

Several specimens were found in situ in borings made by them in blocks of greywacke, which are scattered in a coarse conglomerate underlying the mudstone.

This is the first record of the genus *Parapholas* in New Zealand, the genotype being a Californian Recent species.

Pholadidea thomsoni Suter, 1917 (*N.Z. Geol. Surv. Pal. Bull.*, No. 5, p. 78), from Anthony Bay, Coromandel Peninsula, is not related.

TURBINIDAE.

Genus *SARMATURBO* n.gen.Type: *Turbo superbus* Zittel.*Sarmaturbo superbus* (Zittel). (Pl. 39, figs. 1 and 2, operculum.)1864. *Turbo superbus* Zittel, *Reise der Novara*, Geol. 2, pt. 1, p. 39, pl. 14, f. 2.1929. *Sarmaticus* cf. *superbus* (Zittel) Powell and Bartrum, *Trans. N.Z. Inst.*, vol. 60, p. 413.

In the 1929 paper (Powell and Bartrum) Zittel's *Turbo superbus* was referred tentatively to the genus *Sarmaticus* Gray, 1847, the type of which is the South African Recent *Turbo sarmaticus*, although a single fragmentary specimen of an operculum, presumably of Zittel's species, was found to differ considerably from that of the South African genotype. In 1931, King (*Trans. N.Z. Inst.*, vol. 62, p. 80) described a large "*Turbo*" as *Bolma colini*, the species being closely allied to *superbus*. Now the genus *Bolma* Risso, 1826, has little

in common with these large New Zealand Tertiary shells, being smaller, of lighter build, having finer sculpture, and above all a smooth, polished operculum. In build and sculpture the New Zealand fossils closely resemble *Sarmaticus*, but the opercula of the respective species show them to be quite separable. Recently a number of opercula of *superbus*, together with fragments of the shells, have been taken from the conglomerate at Squadron Bay, and all are found to be heavily sculptured on the under side with deeply incised anastomosing spiral grooves which cut up the central portion into irregular ridges and nodules. In contrast, the operculum of *S. sarmaticus* has the whole inner surface crowded with large irregular stony papillae with no trace of spiral arrangement.

An excellent figure of the *Sarmaticus* operculum is given by Pyecraft in a nature article in the *Illustrated London News*, vol. 187, No. 5034, p. 596, October, 1935.

For these large New Zealand Tertiary *Turbos* I now provide the new generic name *Sarmaturbo* as indicated above, naming *Turbo superbus* Zittel as type and including *Bolma colini* King. Further new species occur at Castle Hill, Canterbury. It is probable that *Sarmaticus* and *Sarmaturbo* had a common origin, but on the evidence of the operculum generic identity cannot be upheld.

NATICIDAE.

Genus MAGNATICA Marwick, 1924.

Type (orig. desig.): *Polinices planispirus* Suter = *Natica suteri* Marwick.

Subgenus SPELAENACCA Finlay, 1926.

Type (orig. desig.): *Magnatica altior* Finlay, 1926.

Magnatica (Spelaenacca) waitemataensis n.sp. (Pl. 39, fig. 3.)

This shell is closely allied to Finlay's *clifdenensis* (*Trans. N.Z. Inst.*, vol. 56, p. 229, pl. 60, fig. 2). It is distinguished by having an even higher mammillate spire, and a more inflated body-whorl, resulting in a "D"-shaped aperture and a deeply concave, appressed suture. Umbilicus as in *clifdenensis*, situated low down, narrow, deep, and almost round, differing in being slightly narrower and in having a less clearly defined "escarpment" step down within the umbilicus, as well as a broader but weaker bounding fold. Spire exactly half the height of the aperture. Whorls $5\frac{1}{2}$, including a small protoconch of $1\frac{1}{2}$ low smooth whorls. Surface smooth and polished, with weak growth lines only.

Height, 37 mm.; diameter, 31.5 mm. (holotype).

Height, 24 mm.; diameter, 21.5 mm. (paratype).

Height, 35 mm.; diameter, 28.5 mm. (holotype of *clifdenensis*).

Locality: Squadron Bay, Waiheke Island, Auckland. Collected by A. W. B. P.

Holotype in Auckland Museum.

ERATOIDAE.

Genus WILLUNGIA nov.

Type: *Willungia tasmanica* n.sp.

A new genus of puzzling affinity, nearest to *Erato*, but differing widely in its globular shape, heavy basal fold (usually bifid) and strong columellar ridges, carried right across the fossula. Typical *Erato* is pyriform in shape and with crenulations rather than ridges on the columella, basal folds hardly distinguishable from the crenulations and always a smooth fossula. On the other hand, *Trivia* and its allies are globular rather than pyriform in shape and have columellar ridges traversing the fossula, but never the heavy basal fold of the new genus.

To this genus belong *Cypraea ovulatella* Tate, 1890 (pl. 39, fig. 5), from Aldinga, South Australia, (Aldingian) Miocene: *Willungia tasmanica* n.sp., which is *Cypraea ovulatella* of Pritchard, 1896 (*Proc. Roy. Soc. Vict.*, vol. 8, n.s.p. 106) not of Tate, from Table Cape, Tasmania, (Janjukian) Miocene: *Marginella fracta* Tomlin, 1916, n.n. for *Marginella ventricosa* Hutton, 1873 (*Cat. Tert. Moll.*, p. 8), from Broken River, Canterbury, N.Z., (Awamoan) Lower Miocene: and *Willungia maoria* n.sp. from Clifden, band 4, Southland, N.Z., (Hutchinsonian-Awamoan) Up. Oligocene-Lower Miocene.

Schilder (1933, *Proc. Malac. Soc., Lond.*, vol. 20, p. 269) has referred *ovulatella* Tate to *Austrocypraea*, but the weak, non-produced posterior canal (a faint sinus only) of *Willungia* is not in accord with that of *contusa* McCoy, the type of *Austrocypraea*. It would appear that *Willungia* represents a primitive Eratoid between *Eratotrivia* Sacco (type: *crenularis* Schilder) and *Architerato* Schilder (type: *pyrulata* Tate).

The genus name was adopted by Dr. H. J. Finlay in manuscript which he generously made available to the writer for publication. The name is based upon Port Willunga, near Aldinga, South Australia, the locality where the first species of the genus was found.

***Willungia tasmanica* n.sp. (Pl. 39, fig. 4.)**

Shell large for the family, globular, much inflated; smooth except for labial and parietal ridges. Protoconch paucispiral, smooth, flattened, of $1\frac{1}{2}$ whorls. Spire very short, about one-thirteenth height of the aperture. Labial varix heavy and rounded, very weakly calloused above on joining the body-whorl. Aperture rather open, slightly crescentic, rather wider below. Anterior canal broad and shallow, posterior canal narrower and indistinct. Outer lip with thirteen sharp ridges; being strongly dentate along the inner margin. Inner lip deeply excavated below, immediately above a strong bifid fold at the base of the columella. The parietal callus bears thirteen spiral to somewhat diverging, long, sharp ridges. These cross the weakly defined but rather broad fossula and extend almost halfway across the front of the body-whorl.

Height, 19 mm.; width, 15 mm. (holotype).

Locality: Table Cape, Tasmania (Janjukian).

Holotype in Auckland Museum (Dr. H. J. Finlay's Collection).

This species differs from *ovulatella* (Tate, 1890) in being much larger, more globular, and in having the parietal ridges extending almost halfway across the front of the body-whorl.

Willungia fracta (Tomlin, 1916). (Pl. 39, figs. 6 and 7.)

1873. *Marginella ventricosa* Hutton, *Cat. Tert. Moll.*, p. 8; not of G. Fisher, 1807.

1916. *Marginella fracta* Tomlin, *Journ. Conch.*, 15, p. 43; n.n. for *M. ventricosa* Hutt.

1918. *Cypraea ovulatella* Suter, *Alph. List N.Z. Tert. Moll.*, p. 12; not of Tate, 1890.

The type is a broken and imperfectly preserved specimen from Broken River, Canterbury, N.Z. Dr. Finlay, who has examined the type, considers it as probably identical with Suter's "*Cypraea ovulatella*" from the Trelissick Basin. A series of poorly preserved specimens from N.Z. Geol. Surv. loc. 241, tuffaceous greensands at Whitewater Creek, Trelissick Basin, appear to be conspecific with a much better preserved, although somewhat distorted specimen from Squadron Bay, Waiheke Island.

This species as represented by the Waiheke shell, differs from the genotype of *Willungia* in having the aperture considerably wider below, with a more shallow and broader anterior canal. Also the labial varix is more massive, particularly medially, and the inner lip plications do not extend far across the body-whorl. Basal fold with a median groove at first but not distinctly bifid. Labial ridges number 12, and there are 11 on the parietal wall in addition to the basal columellar fold.

Height, 18 mm.; width, 14.5 mm. (figured specimen from Squadron Bay).

Locality: Squadron Bay, Waiheke Island, N.Z.

A Trelissick specimen (pl. 38, fig. 6) from locality 241 shows the normal outline for the species. Internal casts from Kakanui tuffs in the collection of Dr. H. J. Finlay may be referred to this species.

Willungia maoria n.sp. (Pl. 39, figs. 8 and 9.)

Shell large, globular, inflation greatest above; labial varix heavy, extending full height of shell. Spire hardly raised (damaged in holotype). Aperture open, slightly crescentic, sides subparallel. Anterior canal shallow, moderately wide; posterior canal shallow but distinct. Outer lip with twelve sharp ridges, strongly dentate along the inner margin. Inner lip with nine strong sharp ridges which do not extend out over the body-whorl; deeply excavated below between the lowest ridge and a strong sinuous fold at the base of the columella.

Height, 19.5 mm.; width, 16.5 mm. (holotype).

Locality: Clifden, Band 4, Southland (holotype); Awamoa Creek, Collection of Dr. H. J. Finlay.

Holotype in Auckland Museum (Dr. H. J. Finlay's collection). Pl. 39, fig. 8.

Although badly crushed, the Awamoa Creek specimen seems to be identical with the Clifden shell.

Schilder, 1936 (*Proc. Malac. Soc.*, vol. 22, pt. 2, pp. 75-112) gives an excellent phylogenetic key to the Cypraeacea. He places *Trivia* and its allies in the Triviinae, a subfamily of the Eratoidae, and follows with the families Lamellariidae, Amphiperatidae and Cypraeidae, in that order.

Below is an attempt to locate the New Zealand Eratoids according to Schilder's classification. Species actually placed by Schilder are marked by an asterisk.

CYRAEACEA.

ERATOIDAE.

ERATOINAE.

Willungia Powell n.gen. Type: *Willungia tasmanica* Powell n.sp.

1. *Willungia fracta* (Tomlin, 1916).

2. *Willungia maoria* Powell n.sp.

Archierato Schilder, 1932. Type: *Erato pyrolata* Tate.

*3. *Archierato antiqua* (Marshall, 1919).

4. *Archierato accola* (Laws, 1935).

Proterato Schilder, 1927. Type: *Erato neozelanica* Suter.

Synonyms: *Sulcerato* Finlay, 1930. *Eratoena* Iredale, 1935. *Lachryma* (Sowerby) Iredale, 1935.

*5. *Proterato neozelanica* (Suter, 1917).

*6. *Proterato awamoana* Schilder, 1933 (n.n. for *E. neozelanica* Murdoch, 1924, *Trans. N.Z. Inst.*, vol. 55, pl. 10, f. 4, not of Suter, 1917)†

*7. *Proterato marshalli* (Marwick, 1929).

*8. *Proterato vulcania* (Marwick, 1926).

9. *Proterato waiauensis* (Laws, 1935).

10. *Proterato waitakiensis* (Laws, 1935).

11. *Proterato sepositum* (Laws, 1935).

12. *Proterato tenuilabrum* (Laws, 1935).

13. *Proterato clifdenensis* (Laws, 1935).

14. *Proterato pukeuriensis* (Laws, 1935).

Proterato (*Cypræerato* Schilder, 1932). Type: *Erato bimaculata* Tate.

*15. *Proterato* (*Cypræerato*) *senectus* (Murdoch, 1924).

16. *Proterato* (*Cypræerato*) *submorosa* (Laws, 1935).

† Schilder, 1933, Monograph of the Subfamily Eratoinae, *Proc. Malac. Soc.*, vol. 20, p. 268.

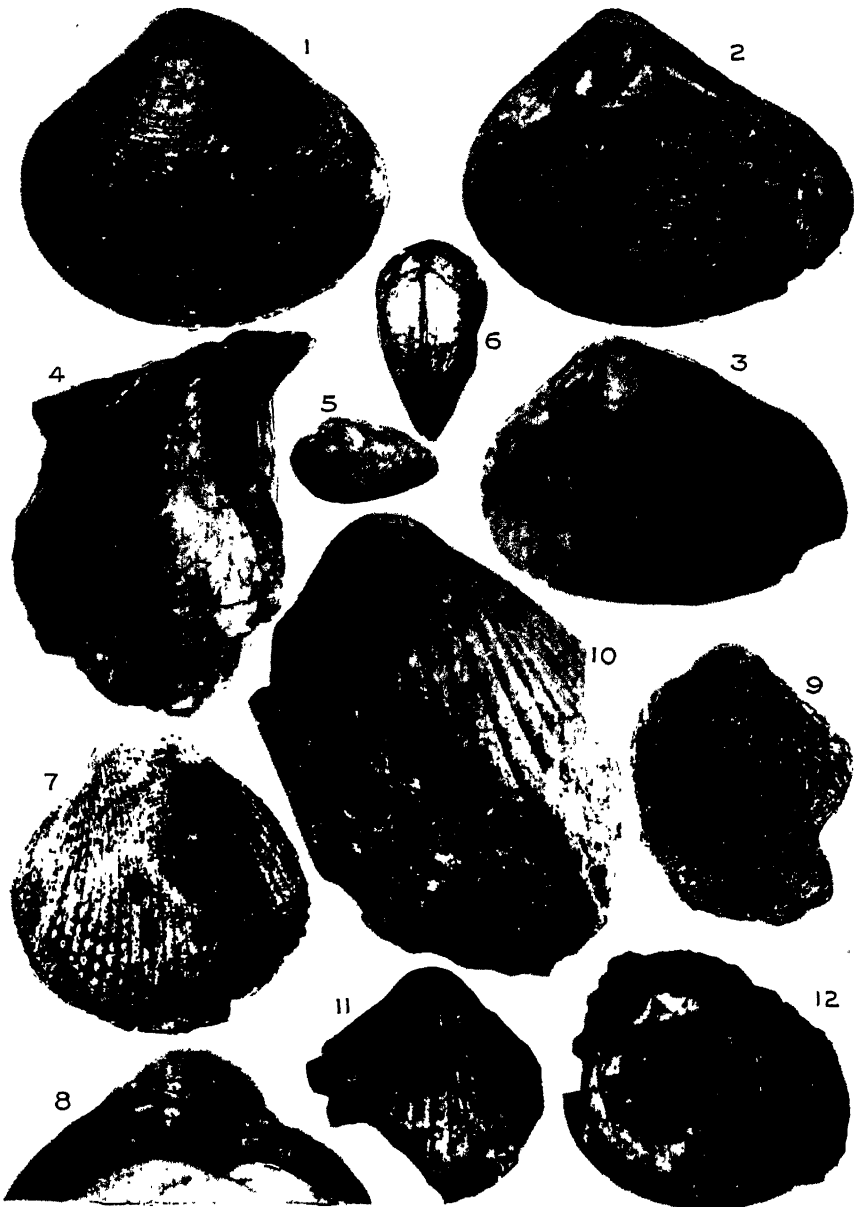
CYMATIIDAE.

Genus *MAYENA* Iredale, 1917.

Type (orig. desig.): *Biplex australasia* Perry.

Mayena bartrumi n.sp. (Pl. 39, fig. 12.)

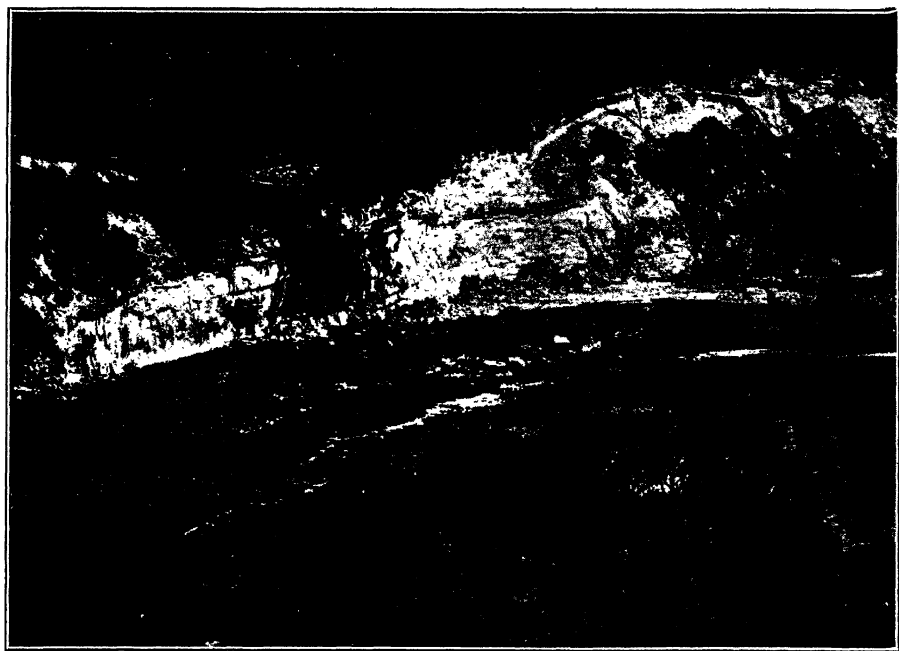
Shell of moderate size, fusiform; strongly variced at slightly more than half-whorl intervals. Spire slightly less than height of aperture plus the short canal. Nuclear whorls missing; post nuclear whorls 5. Sculpture of 3 equispaced rows of strong rounded nodules on the body whorl; on the spire, only the uppermost of these occurs and is placed medially; the second just shows at the suture towards



FIGS. 1 and 2.—*Eucrassatella ampla* (Zittel), Squadron Bay, Walheke. FIG. 3.—*Eucrassatella attenuata* (Hutton), Target Gully, Oamaru. FIG. 4.—*Pteria oneroensis* (Powell and Bartrum), Neotype. FIG. 5.—*Parapholas aucklandica* n.sp.: Holotype. FIG. 6.—*Parapholas aucklandica* n.sp.: Paratype. FIGS. 7 and 8.—*Cardium oneroensis* n.sp.: Holotype. FIG. 9.—*Glycymeris (Grandaxinea) aucklandica* n.sp., Holotype. FIG. 10.—*Venericardia (Megacardita) squadronensis* n.sp., Holotype. FIGS. 11 and 12.—*Venericardia (Megacardita) squadronensis* n.sp., Paratypes.



FIGS. 1 and 2.—*Sarmaturbo superbus* (Zittel), Operculum. FIG. 3.—*Magnatica* (*Spelaenacca*) *waitemataensis* n.sp., Holotype. FIG. 4.—*Willungia tasmanica* n.gen. and sp., Holotype, Table Cape, Tasmania. FIG. 5.—*Willungia ovulatella* (Tate), Topotype, Aldinga, S. Australia. FIG. 6.—*Willungia fracta* (Tomlin), Trellissick Basin, Canterbury. FIG. 7.—*Willungia fracta* (Tomlin), Squadron Bay, Waiheke. FIG. 8.—*Willungia maoria* n.sp., Holotype. FIG. 9.—*Willungia maoria* n.sp., Awamoa Creek. FIGS. 10 and 11.—*Euspinacassis oneroanensis* n.sp., Holotype. FIG. 12.—*Mayna bartrumi* n.sp., Holotype. FIG. 13.—*Scutellastra cooperi* n.sp., Paratype. FIG. 14.—*Scutellastra cooperi* n.sp., Holotype. FIG. 15.—*Cookia karekarensis* n.sp., Holotype. FIG. 16.—*Austrotoma finlayi* n.sp., Holotype. FIG. 17.—*Austrotoma finlayi* n.sp., Paratype. FIG. 18.—*Haliotis flemingi* n.sp., Holotype. FIG. 19.—*Haliotis* (*Notohaliotis*) *waitemataensis* n.sp., Holotype.



Fossiliferous bed half mile N.W. of Oneroa Beach, Waiheke Island. The original site described by Powell and Bartrum (1929).

the end of the penultimate whorl. There are six of these nodules between each pair of varices. On the early whorls and on the shoulder only of the later whorls there are numerous, somewhat irregular, narrow and flexuous axial folds. The whole shell, nodules included, is crossed by well-marked dense spiral striations. The varices are heavy rounded flanges very slightly buttressed from behind adjacent to the nodular rows, and margined at the front by the thin recurved edge of the outer-lip callus. Aperture narrowly ovate, notched above and with a short narrowly open straight canal below. Inner-lip callus broad and smooth with a small parietal tubercle and several weak denticles below. Outer lip reflected, weakly denticulate along the inner edge and terminating externally as a thin-edged flange separated from the labial varix by a deep narrow groove.

Height, 67 mm.; diameter, 35 mm. (holotype).

Holotype in the writer's collection, Auckland Museum.

Locality: Squadron Bay, Waiheke Island, Auckland. Collected by A. W. B. P.

This species is allied to *Cymatium kaiparaensis* Finlay, 1924, and *C. sculpturatum* Finlay, 1924, both of which were later referred to *Mayena* by their author (*Trans. N.Z. Inst.*, 57, p. 400).

The new species is characterised by having blunt tubercles combined with fine subsidiary spirals.

Genus PROXICHARONIA nov.

New name for *Charoniella* Powell and Bartrum, 1929 (not *Charoniella* Thiele, 1929, *Handb. Syst. Weicht.*, I, p. 283).

Type: *Charonia* (*Charoniella*) *arthritica* Powell and Bartrum.

Proxicharonia arthritica Powell and Bartrum, 1929.

1929. *Charonia* (*Charoniella*) *arthritica* Powell and Bartrum, *Trans. N.Z. Inst.*, vol. 60, p. 445.

Unfortunately the name *Charoniella*, proposed as a subgenus of *Charonia* by Powell and Bartrum for the Waiheke species *arthritica*, is invalidated by Thiele's use of the same name for an Australian species *Triton subdistortus* Lamk. Iredale's genus *Negyrina* 1929 (September 4th) proposed for the same Australian shell, has slight priority over Thiele's *Charoniella*, but as Powell and Bartrum's proposal did not appear until November 30th, it is necessary to provide a new name for the New Zealand *Charoniella*.

The local *Charoniella* was proposed as a subgenus of *Charonia*, to which it is distantly related, but the three species ascribed to it by its authors form such a compact group (each having the characteristic distorted growth discordant with *Charonia* and reminiscent of *Distorsio*) that full generic rank is desirable.

A second specimen was found at Squadron Bay, Waiheke Island.

CASSIDIDAE.

Genus *EUSPINACASSIS* Finlay, 1926.Type (orig. desig.): *Euspinacassis pollens* Finlay.*Euspinacassis oneroaensis* n.sp. (Pl. 39, figs. 10 and 11.)

Shell of medium size, massive, encircled with numerous rows of strong blunt tubercles; aperture heavily variced and calloused within; canal very short, deeply notched. Apex erect, dome-shaped, of three smooth regularly-coiled whorls, nucleus minute. Spire one-fourth height of aperture. Five spiral rows of nodules on the body-whorl, only the uppermost showing on the spire-whorls. Between the lowest spiral row of nodules and the fasciole are three flat-topped subsidiary spiral cords without nodules. The nodules on the uppermost spiral number eleven on the body-whorl; they are subspinose; those on the lower spirals number fourteen, and are bluntly rounded. Whole surface overlaid with fine crowded spiral lirations. Aperture narrowly ovate. Outer lip with a very heavy varix, reflexed, and bearing weak denticles along the calloused inner edge. Parietal callus: thick and spreading, with irregular plait-like ridges on the pillar, and bridging across the deep umbilical chink.

Height, 44 mm.; diameter, 31 mm. (holotype).

Locality: Oneroa, Waiheke Island (small bay $\frac{1}{2}$ mile N.W. of Oneroa Beach).

Holotype in the writer's collection, Auckland Museum.

This species is nearest allied to *Xenophalium toreuma* Powell, 1928 (*Trans. N.Z. Inst.*, 59, p. 636) from volcanic tuffs at Motutara, West Coast, Auckland, and appears to be directly ancestral to it. The Waiheke species differs from *toreuma* in having a shorter spire with only the uppermost row of nodules showing on the spire whorls.

Rutsch ("Zur Nomenklatur und Systematischen Stellung einiger tertiärer Cassididae aus Neu-Seeland," Sonderabd. aus dem Ber. über die elfte Jahresversammlung der Schweizerischen Paläontologischen Gesellschaft, *Eclogae geologicae Helvetiae*, Band 24, No. 2, p. 252, 1931) synonymises Finlay's *Euspinacassis* with the European Tertiary *Echinophoria* Sacco, 1890, and at the same time expresses the view that *Echinophora* Leske, 1778, does not invalidate Sacco's *Echinophoria*. I hesitate to accept Rutsch's conclusions without having access to specimens of the genotype of *Echinophoria* Sacco.

MURICIDAE.

Genus *VESANULA* Finlay, 1926.Type (orig. desig.): *V. chaskanon* Finlay.*Vesanula waitemataensis* (Powell and Bartrum, 1929).1929. *Zeatrophon waitemataensis* Powell and Bartrum, 1929, *Trans. N.Z. Inst.*, vol. 60, p. 436.

Better preserved material has necessitated a change to the above genus, as suggested to the writer by Dr. H. J. Finlay.

NASSARIIDAE.

Genus HIMA Gray, 1852.

Type (Woodring, 1928): *Buccinum minutum* Pennant
(= *B. incrassatum* Strom.).

Subgenus MIRUA Marwick, 1931.

Type (orig. desig.): *Nassa socialis* Hutton.**Hima** (*Mirua*) aff. *socialis* (Hutton, 1886).

A single specimen from Squadron Bay cannot be removed from the matrix with safety. It is close to *socialis*, but has the axial ribs more numerous on the last whorl.

TURRIDAE.

Genus RUGOBELA Finlay, 1924.

Type (orig. desig.): *Ptychotractus tenuiliratus* Suter.**Rugobela sepelebilis** (Powell and Bartrum, 1929).1929. "*Guraleus*" *sepelebilis* Powell and Bartrum, *Trans. N.Z. Inst.*, vol. 60, p. 441.

This species should now be referred to the above genus.

Genus AUSTROTOMA Finlay, 1924.

Type (orig. desig.): *Bathytoma excavata* Suter.**Austrotoma finlayi** n.sp. (Pl. 39, figs. 16 and 17.)1929. *Austrotoma excavata* (Suter), Powell & Bartrum, not of Suter, 1917.

I am indebted to Dr. H. J. Finlay for the opinion that the 1929 record of "*excavata*" from Oneroa is not that species, but a new one closely related to a new species from Otiake, Waitaki Valley. True *excavata* is almost smooth and more inflated medially.

The Waiheke species is distinguished by its slender shape and tall spire, which equals the aperture in height. The paratype (pl. 38, fig. 17) shows the normal proportions of spire to aperture, while the holotype (pl. 38, fig. 16) exhibits the sculpture very clearly. The extra long spire of the holotype is the result of lateral squeezing in the matrix.

Description of holotype. Shell rather large, narrowly fusiform; spire normally not quite as high as aperture plus canal. Whorls 10, including a typical, conoid, small, smooth, multispiral protoconch of three whorls, followed by a half whorl bearing 8 fine spirals. Spire whorls strongly angled and keeled at a little below the middle, shoulder deeply concave. Sculpture of well-defined, flat-topped, spiral cords with a fine thread in each interspace. The main spirals number two on the upper whorls and three on the lower whorls, between the broad-rounded keel and the lower suture. The keel may be smooth, but more often it is as in the holotype, composed of three more closely spaced additional spirals. Between the peripheral keel and the upper suture there are seven finer cords, the middle four being weaker than the pairs above and below them respectively.

On the body-whorl there are fifteen main cords below the keel. The axial sculpture consists of fourteen weak axial folds, which disappear after the fourth post-nuclear whorl. Fasciole distinct, bounded by a thin sharply raised cord and sculptured with six spiral threads, the upper three being the stronger.

Height, 57 mm.; diameter, 19 mm. (estimated), 21.5 mm. (actual: specimen crushed) (holotype).

Height, 45 mm. (estimated); diameter, 18.5 mm. (paratype).

Holotype in writer's collection, Auckland Museum.

Locality: Oneroa.

VOLUTIDAE.

Genus *Waihaioia* Marwick, 1926.

Type (orig. desig.): *W. allani* Marwick.

Waihaioia n.sp.

Two badly crushed specimens allied to *phymatius* (Finlay, 1926) were found at Squadron Bay, Waiheke Island, but this material is barely sufficient for the founding of a new species. The Waiheke shells have the same sparse enlarged tubercles as *phymatius*, but the spire is much shorter and the local shells attain a larger size.

MOLLUSCA FROM TERTIARY BED EAST SIDE OF BOSTAQUET BAY, KAWAU ISLAND.

W = found also in the Waiheke faunules.

Class PELECYPODA.

Class GASTEROPODA.

Pallium burnetti (Zittel, 1864).

Ostrea (*Gigantostrea*) *gittosina* Powell and Bartrum, 1929.

W. *Eucrassatella ampla* (Zittel, 1864).

W. *Venericardia* (*Megacardita*) *squadronensis* n.sp.

Miltha (*Milthoidea*) *dosiniiformis* Marshall and Murdoch, 1921.

*Divalucina** aff. *cumingi* (Ad. and Ang.).

W. *Cardium* (*Trachycardium*) *greyi* Hutton, 1873.

Haliotis (*Notohaliotis*) *waitemataensis* n.sp.

Haliotis (*Notohaliotis*) *flemingi* n.sp.

Astraea n.sp.

Cookia kawauensis n.sp.

W. *Sarmaturbo superbus* (Zittel, 1864).

W. *Zegalerus* cf. *peramplus* Powell and Bartrum, 1929.

W. *Struthiolaria* spec. indet. (prob. *lawsei* Powell & Bartrum, 1929).

W. *Morum* (*Oniscidia*) *harpaformis* Powell and Bartrum, 1929.

* Iredale, 1936, *Rec. Aust. Mus.*, vol. 19, no. 5, p. 273.

HALIOTIDAE.

Genus HALIOTIS Linné, 1758.

Type (subsequent designation, Montfort, 1810): *Haliotis asinina* Linn.

Subgenus NOTOHALIOTIS Cotton and Godfrey, 1933.

Type (original designation): *Haliotis naevosa* Martyn.***Haliotis (Notohaliotis) waitemataensis* n.sp. (Pl. 39, fig. 19.)**

Shell of moderate size, ovate, much depressed; sculptured with imbricating strong radial folds crossed by spiral cords of three sizes. On the penultimate whorl there are five well-defined equispaced cords which increase in strength and persist over the body-whorl. Intermediates commence after the first post-nuclear whorl, there being in each of the interspaces between the main ribs a subsidiary median rib with a finer rib in the interspace on each side of it. The radials and the main spirals are five millimetres apart respectively at the middle of the body-whorl. Space between perforations and lower margin of shell spirally ribbed, but the number is indefinite owing to adherent matrix. Protoconch worn, one-third of the length from the left margin and less than a third of the width from the front margin. Perforations distinctly raised, tubular, and numbering about 21 on the body-whorl.

Length, 56 mm.; width, 46 mm.; height (estimated), 17 mm. (holotype).

Holotype in the writer's collection, Auckland Museum.

Locality: East side of Bostaquet Bay, Kawau Island, in sandy limestone. Collected by A. W. B. P.

The indeterminable specimen recorded from Oneroa, Waiheke Island, by Powell and Bartrum (1929, *Trans. N.Z. Inst.*, 60, p. 445), but not collected, was probably this species.

***Haliotis flemingi* n.sp. (Pl. 39, fig. 18.)**

Shell of moderate size, ovate, depressed; sculptured with somewhat irregular arcuate forwardly directed radial folds. There appears to be no spiral sculpture. There are fourteen of the radial folds on the last whorl. Nucleus at about one-third of the length from the left margin (allowance being made for slight distortion of the specimen). Perforations slightly raised, 14 on the last half-whorl. Space between perforations and lower margin of shell appears smooth.

Length, 78 mm.; width, 55 mm.; height (estimated), 19 mm. (holotype).

Holotype presented to the Auckland Museum by Mr. C. A. Fleming.

Locality: East side of Bostaquet Bay, Kawau Island, in sandy limestone. Collected by Mr. C. A. Fleming, 1934.

This species is ancestral to the Recent *australis* Gmelin, from which it differs in the absence of spiral sculpture, fewer radials, and the nucleus being nearer to the middle.

The two species described above are of special interest, as they make the earliest known occurrence of *Haliotis*. Probably the genus is of much greater antiquity, for rock-clinging organisms are very rarely preserved as fossils. Woodring, 1931, and 1932, records two Miocene species from California, and there are several Australian Tertiary species from Miocene localities.

TURBINIDAE.

Genus *ASTRAEA* Bolten, 1798.

Type (desig. by Suter, 1913): *Trochus heliotropium* Martyn.

Astraea n.sp.

This is a new species differing from the genotype in being much more depressed, more sparsely sculptured and in having bluntly-rounded peripheral processes and a very shallow umbilicus. Unfortunately, the available material is inadequate for providing a recognisable description.

Locality: East side of Bostaquet Bay, Kawau Island.

Material in Auckland Museum collection (1 sp.) and the writer's collection (2 sps.).

Genus *COOKIA* Lesson, 1832.

Type (monotypy): *Astraliium sulcatum* Martyn.

Cookia kawauensis n.sp. (Pl. 39, fig. 15.)

Shell large, conic, probably imperforate. Whorls probably seven (only five showing owing to eroded apex). Sculpture of strong, oblique, forwardly-directed, flexuous, rounded, fold-like axials, each terminating at the lower suture or periphery in blunt massive tubercles. These axials are about sixteen per whorl. Encircling the middle of each whorl is a slightly depressed zone caused by the axials being reduced in strength medially. Suture deeply impressed, undulating.

Height, 73 mm.; diameter, 80 mm. (estimated).

Locality: East side of Bostaquet Bay, Kawau Island. Collected by A. W. B. P., 1927.

Holotype in writer's collection, Auckland Museum.

The holotype, the only specimen collected, is very imperfect, but is named, as nothing much better is likely to be found in the Kawau beds. It is of interest also to record a Tertiary ancestor to the Recent species.

MOLLUSCA FROM TERTIARY BED ON SOUTH SIDE OF MOTUIHI ISLAND.

PECTINIDAE.

Genus *SERRIPECTEN* Marwick, 1928.

Type (orig. desig.): *Pecten hutchinsoni* Hutton.

Serripecten beethami (Hutton, 1873).

One fairly complete right valve of medium size (height, 69 mm.; length, 80 mm.).

PATELLIDAE.

Genus SCUTELLAstra H. & A. Adams, 1858.

(Three species cited: *gorgonica* Humph., *pentagona* Born, and *plicata* Born.)Type (here selected): *Patella gorgonica* Humph. = *P. longicosta* Lamk.***Scutellastra cooperi* n.sp.** (Pl. 39, figs. 13 and 14).

Shell fairly solid, depressed, star-shaped, having eight principal ribs, which are carinated and strongly projecting at the margins. There are from three to five secondary rounded ribs in the interspaces between the primaries. Apex (eroded away) at about the anterior third. Margins strongly indented between the primary ribs.

Length, 50 mm.; breadth, 38 mm.; height, approx. 9 mm. (holotype), (pl. 38, fig. 14).

Locality: Motuihi Island, midway along the south coast, Auckland. Collected by the late Mr. Charles Cooper.

Holotype and paratype in the Charles Cooper Collection, Auckland Museum.

This species, although represented by very imperfect material, is almost certainly a *Scutellastra*, closely resembling the South African *longicosta* group. The few carinate ribs, with deeply indented margins, are characters foreign to any *Cellana* known to me; and, further, typical species of *Cellana* occur in local beds of the same horizon.

Scutellastra is considered to be a genus of considerable antiquity, and its present wide distribution in the Southern Hemisphere is interpreted as providing some indication of the probable extent of the hypothetical "Gondwanaland" continent of geologists. Recent species of *Scutellastra* have their greatest development in South Africa, but others occur at Mauritius, Reunion, South Western Australia, Philippine Islands, Melanesia, Polynesia, and the Kermadecs. As far as I am aware, no fossil species is on record, and a genus is hereby added to the New Zealand Tertiary fauna.

The Ill-conditioned Trout Present in the Lower Selwyn During the Spring of 1932.

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[*Read before the Canterbury Branch, April 6, 1938; received by the Editor, May 4, 1938; issued separately, December, 1938.*]

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INTRODUCTION.

THE effects of the artificial stripping of trout as practised at Lake Ellesmere by the North Canterbury Acclimatisation Society are discussed by Professor Percival (1937) in a paper criticising certain brief statements on this subject made in the introduction to a paper by the present author (1936), and as it is fitting that some account other than that of a member of the body concerned should be placed on record the following particulars are submitted.

The fish concerned are migratory trout from Lake Ellesmere, which are distinguished from the permanent residents of the shingly part of the Selwyn River by the microscopic structure of their scales and by their dentition. The scales of lake-dwelling fish show comparatively poor definition between the summer zones and the winter zones in the section formed between the parr stage and the attainment of maturity, and also disclose a much more rapid growth rate than those of river-dwelling fish. Figure 1 shows a micrograph of a Lake Ellesmere scale and Figure 2 one from a river-dwelling fish, both photographed at the same magnification. The river scale shows the structure sharply contracted at the winter bands followed by wider spacing of the ridges representing the parts of the scale formed in the summer or growing periods. In the lake scale the structure is much more uniform; the spacing of the ridges in the winter band, the edge of which is marked W.B. in the photograph, is only slightly closer than in the summer zones that precede and follow it. It is further to be noted that erosion consequent on sexual maturity is quite common in Lake Ellesmere scales, but in those of permanent residents of the river it can seldom be detected.

The second character by which migratory trout may usually be distinguished from permanent residents of the river is the vomerine teeth. In Lake Ellesmere trout there is a definite tendency for these teeth to be lost from the rear in adult fish. Some specimens have only one or two teeth left on the head of the vomer, while in others there are only one or two missing at the rear, and in extreme examples

the row is complete. It follows, therefore, that the existence of a complete row of teeth on the vomer does not necessarily identify a fish as river-dwelling, but a fish with a vomer partly or completely denuded of teeth may definitely be regarded as migratory. Figures 3 and 4 show the dentition of the two classes of fish.

THE CONDITIONS EXISTING IN 1932-33-34.

The winter and spring of 1932 were remarkable for the complete absence of floods in the Selwyn River. At the opening of the fishing season on October 1st the river was unseasonably low with the lower water extending upstream only to Hadstock, a few miles above which the course became entirely dry and continued so to within a short distance of the mouth of the Hororata. The deeper pools throughout the shingly section of the lower permanent water contained large ill-conditioned trout of a size much greater than that of the permanent residents of this locality, but agreeing with that of the fish composing the spawning run from Lake Ellesmere. In some pools only a few fish were visible, while in others such as the large pool just below Meadowbank upwards of 50 were counted. Many dead fish, skeletons, skulls and vertebrae, all agreeing in size with the large ill-conditioned fish in the pools, were found stranded at the water's edge, and others were obtained from the water by dragging. A considerable stock of young trout of up to about 5 inches in length was present, and there was a scattering of fish of from half a pound to a pound or more in weight.

A group of twenty of the ill-conditioned fish was collected for investigation, seventeen being taken by the writer and a companion by angling in pools in the shingly part of the river, and three being obtained from anglers fishing the deep section near the mouth. The fish ranged in length from 17 inches to 22½ inches and showed an average for the group of 18.2 inches. By the methods indicated above all were identified as Lake Ellesmere trout. The condition factor as determined by Corbet's calculator, which is based on the formula $\frac{\text{Weight in pounds} \times 100,000}{\text{Length in inches cubed}}$, showed the low average of 31. The suggestion put forward by Professor Percival (*loc. cit.*, p. 348) that the failure of these fish to regain condition in the river was due to lack of a stimulus to feed in the form of a flood or fresh is not only purely speculative but discloses a lack of acquaintance with the habits of Lake Ellesmere trout. These fish never regain condition while upstream on their spawning migration, and their failure to do so in the present instance requires no explanation. The onset of maturity is accompanied by a discontinuance of normal feeding (see tables 1 and 3 in the original paper), and during the reproductive period the fish exist on bodily reserves, condition being regained only after return to the lake. It sometimes happens that lake fish become land-locked in the permanent water above Coalgate, where they may exist for a year or more before return to the lake becomes possible, and during this enforced upstream residence they adopt, to some extent, the feeding habits of river-dwelling fish, but either through insufficiency or unsuitability of the food available or disinclination of the fish to seek it in the shallower and more rapid

parts of the stream their condition remains much lower than that of the small permanent residents of the river. The remarkable thing about the ill-conditioned trout of 1932 is not that they failed to regain condition in the river, but that they remained upstream so long after the spawning season when there was no obstacle to their downward passage, and it was for the purpose of determining the cause of this abnormal behaviour that specimens were collected and examined.

Upon dissection the group proved to be composed of eighteen females and two males, the latter being among the specimens taken upstream. The presence of fully-developed eggs, ranging in number from nine to one hundred and forty-six, in all females examined indicated that all had reached maturity and that most of the eggs developed by each fish had been parted with. The majority of the eggs present were lying free in the body cavity, but in some specimens a few eggs were retained within the ovaries; others had eggs lodged between the liver and the structure that is referred to by Gunther (1880) as the diaphragma, by Kendall (1920) as the diaphragm, and by Percival (*loc. cit.*, p. 346) as the abdomino-pericardial wall, and in four there were eggs embedded in the liver. The latter organ was, in one specimen, much broken up, with eggs present in the interstices of the mass. More than half the specimens examined showed discolouration of parts of the liver, usually associated with a roughening of the surface and a shrinkage of the parts affected. These parts when sectioned, revealed considerable breaking down of structure. The ovaries of all females examined were damaged in a greater or less degree. In one specimen the left mesovarium was parted from its anterior and dorsal anchorage for about three-quarters of its length and was turned back with its anterior end to the rear of the body cavity, the partly detached membrane showing several rents and openings. The right mesovarium, which had retained its position, had five rents extending transversely from the free edge, two of these rents having formed a flap which had turned inwards and appeared to be in the process of forming an egg-retaining pocket such as is frequently observed in Lake Ellesmere trout. The least damaged specimen had one ovary uninjured and only a slight transverse rent toward the rear of the other. Between this extreme and the specimen first described there was complete intergradation, the injuries being identical in character and differing only in severity. The genital organs of the two males examined showed no definite evidence of injury.

In three specimens the lower intestinal mesentery disclosed injuries consisting of holes through the membrane, partings from the point of anchorage and the tearing back of the vertical face, and in two the upper intestinal mesentery was injured in a similar manner. These injuries were usually almost healed and had obviously been inflicted some time previously. Eight specimens revealed one or more ruptures of the peritoneum, most of which were in process of healing, but in two the structure of a considerable area of peritoneum together with that of much of the adjacent muscle was completely broken down. The continuance in life of these fish must necessarily have been brief.

In most specimens the muscular structure of the abdominal wall showed considerable inflammation, this being most severe in the region between the ventral fins and the genital outlet. Three specimens, including the two males, showed only slight inflammation, which would probably have passed away in a short time. One specimen had a large portion of the spleen almost severed from the remainder while in two others small portions had been detached at the posterior extremity. In a few instances the intestinal wall showed breaking down of structure.

Externally the fish showed no trace of recent injury. Two specimens possessed old scars, but the scale covering had been completely replaced on the parts affected, and by examination of the replacement scales the date of injury was determined to be over two years previously in one specimen and nearly two years in the other, the date of injury in each instance preceding the attainment of maturity. A similar percentage of scarred fish is normal in all collections of mature Lake Ellesmere trout. With the exception of one specimen taken near the river mouth, which contained seven smelts, the stomachs of the fish examined were almost empty.

The ill-conditioned fish remained upstream in the pools and continued to die off until October 25 when a flood occurred and they were washed away, their places being taken later by stragglers from the Hororata and the upper permanent water of the main stream. No further flood occurred during the summer, autumn and winter, and in the spring of 1933 conditions were identical with those of the previous year. It is stated on page 348 of the paper under discussion that in September, 1933, there were many large ill-conditioned fish lying in pools about ten miles from the river mouth, and that these fish would not leave the pool although there was free egress; and it is further stated that at the end of September a slight freshet occurred and the fish disappeared. The latter statement is not correct. There was no freshet, rise or discolouration of the water in September, 1933, and there was no noticeable movement of fish in this month or the following month. At the opening of the fishing season on October 1st the river was very low with an abnormal development of algae, and the pools in the locality indicated contained a greater number of large ill-conditioned fish than had been present in the previous year. Reference to the writer's diary shows that on October 1st, 1933, over thirty large fish were visible in Butterfield's Pool, about twenty in Plunket's Pool, nineteen in the Meadowbank Pool, and over seventy in the Clay Block Pool. This pool affords considerable facilities for the concealment of fish, and it is probable that double the number counted was present. The Aquarium carried a large shoal, the full extent of which could not be determined on account of the deep shade, there were eleven fish in the Moonlight Pool, about twenty-five in the Swirl, between thirty and forty in McGregor's Pool and a small shoal in the Secrecy Pool. The intervening sections of the river carried many individual specimens and small groups. The fish gradually dwindled away during the first two months of the season, some dying and many being taken by anglers. Specimens were procured by the writer on the 2nd and 5th of October and, on examination, were found to be identical with

those of previous year; all were mature Lake Ellesmere trout, and all possessed internal injuries of the nature described but were free from external marks. The fish examined this season were invariably females.

In the winter of 1934 several floods occurred, and, at the opening of the fishing season, no injured fish were found in the shingly part of the river, but the majority of those taken by anglers fishing in the lake off the river mouth and by flounder fishermen operating in the same locality were in poor condition and injured in the manner described above. Of thirty-nine specimens taken from the lake only four were well conditioned, three of these being immature and the fourth a large fish that had spawned three times, in none of which was any internal derangement visible. It may further be briefly stated that injured fish were not peculiar to the three seasons mentioned, that they were present in various numbers in many previous years, and that specimens have been observed in subsequent ones.

It will thus be seen that the existence of large ill-conditioned fish in the spring is not controlled by weather conditions and the consequent state of the river, but that the precise locality in which they are to be found is so. The absence of winter or spring floods allows the damaged fish to lie quietly in upstream pools where their presence is easily detected, but when floods occur they are washed bodily into the lake where they die or recover out of sight.

THE CAUSE OF THE INJURIES.

The injuries described form so complete an explanation of the abnormal behaviour of these fish in remaining upstream instead of returning to the lake in the natural manner that the matter resolves into the question of how the injuries were received.

Professor Percival, who, incidentally, has publicly admitted that he did not examine a single specimen, suggests two explanations. The first explanation, that the injuries were really not injuries at all but merely the effects of post-mortem changes, would require, on the present author's part, an ignorance of the universally known fact that fish undergo rapid decomposition after death. The second speculation, that the injuries were caused by dynamiting, is consistent with neither the effects produced by the use of explosives nor the conditions existing on the river at the time. In view of the fact that dynamited fish are killed by concussion, and that death is usually brought about without visible external or internal injury being caused, it is impossible to believe that a fish could survive a shock capable of causing serious disruption of internal structure, even if the latter result were mechanically possible. There was, moreover, none of the conditions that accompany the use of dynamite in such a stream. The most noticeable feature of all dynamited pools that have come under the writer's observation is the presence of small dead fish, of from four to six inches in length, which either show conspicuously from the bottom or drift down and become stranded on the shallows below. The complete absence of such dead fish from the dozen or more pools examined, together with the failure to discover bones of corresponding size, is satisfactory evidence that no dynamiting had occurred for a considerable period.

A further suggestion made on page 348 of the paper under discussion, that injury may have been suggested by the somewhat ragged appearance of the ovaries, which, it is stated, normally remain flabby for many weeks after the eggs are shed, is irreconcilable with the statement made on page 345 that shrinkage of the ovary occurs before the eggs are discharged from the body, and cannot be considered.

In addition to these suggested explanations of the injuries present in the ill-conditioned trout of 1932, evidence is presented in opposition to the present writer's conclusions that stripping was responsible. It is implied on pages 347 and 350 of the paper under discussion that trout do not proceed upstream after being stripped, and that injuries present in fish collected some miles above the trap could not have been caused by stripping.

Discussing the artificial spawning of trout, Mr W. H. Armistead, proprietor of the Solway fishery, and one of the leading fish-culturists in Great Britain, states (1908) :—

Spawned fish should be put into the stream above the trap, if there is no fear of poachers. Most of them will journey up to the spawning beds and deliberately go through the whole performance of making redds, etc., as though they were quite unaware of the fact that their eggs had been taken from them.

Speaking on the same subject during the discussion on Kendall's (1920) anatomical paper, Mr J. W. Titcombe, fish culturist, Conservation Commission, Albany, New York, says :—

In the case of wild fish held in pens and stripped from day to day, I have found that if in stripping we leave one or two eggs the trout will stay around the spawning bed until it gets rid of those eggs. We find they are very persistent. We have penned fish two miles from the spawning beds and taken what we believed to be all their eggs, and within twenty-four hours we have found those same fish over on the spawning beds two miles away. I inferred that these fish were there to get rid of the two or three eggs we had left behind in the stripping process.

This statement is referred to by Percival (*loc. cit.*, p. 347) as follows :—

It is probable that Titcombe's phrase "one or two eggs" means perhaps half stripped or thereabouts.

As the grounds upon which this assumption is based are not stated it is unnecessary to attempt any reconciliation between it and Titcombe's high standing as a fish-culturist.*

* Since the above was written an experiment has been conducted for the purpose of determining the post-stripping behaviour of migratory trout in local waters. With the permission of the North Canterbury Acclimatisation Society, to which thanks are proffered, the writer liberated 80 stripped fish above the Selwyn trap after they had been rendered sufficiently conspicuous for detection in moderately deep water by the attachment of a white celluloid tag to the dorsal fin. The tagging was performed on June 27, 1938, at a trap erected at Boyles ford, about 8 miles above the usual scene of stripping operations. Both sexes were handled, about half the fish being stripped on the same day as tagging was performed, while the remainder had been stripped the previous day and retained in the pen. The river had recently been in flood, but was perfectly clear, although a large stream was flowing. Upon release above the trap after being tagged, active fish immediately proceeded up and across stream, usually becoming lost to sight after proceeding about three chains. Sick fish sheltered for some time alongside weed banks in the vicinity of the point of liberation or alongside the wire netting of the pens, four fish being visible in

A section of the paper under discussion is devoted to a consideration of the ovarian anatomy of trout, and the conclusion is reached therefrom that "it is not clear how eggs could be forced forward in the body cavity when a ripe fish is held upsidedown preparatory to stripping." As no such suggestion was made by the present writer, the words used being "head downward" (Stokell, 1936, p. 81), no further comment is required.

The suggestion is made (Percival, *loc. cit.*, p. 350) that since the act of stripping females may be regarded as more vigorous than with males, there should be shown some reflection on the sex ratio of fish handed in successive years if stripping were injurious. Without presuming to express an opinion on the first contention the present writer submits that, if it is a valid one, a test could more logically be applied to the fish in which injuries existed than to those taken each year in the traps, many of which are necessarily first spawners and cannot have come under the influence suggested. Actually the percentage of females in the injured fish examined, including those from the lake, was 94.

It is further suggested on pages 349 and 351 of the paper under discussion that if stripping were injurious to trout the loss of a number of mature fish would tend to affect the higher age groups, thus causing a reduction in the average size of fish handled at the traps in successive years, and it is contended that as no appreciable reduction in average size is revealed by the table of weights and lengths presented on page 349 the population has remained constant. It is not clear how the extent of a trout population may be judged in this manner when only an inconstant fraction of the spawning-run is dealt with and the ages of the fish are unknown. A reduction in the population could be expected to render an improved food supply available to the remaining fish, and this could conceivably be reflected in an improved growth rate and consequently a higher average size. There are also other influences operating at Lake Ellesmere which tend to disqualify any inference of a numerically constant population that may be drawn from a constant average size. The standard mesh of the flounder nets, which permits the passage of small mature trout but retains and kills larger individuals, must be considered as an influence in regulating the average size of adult trout, and the same may be said of the effects of parasitism, which have been found to become progressively more potent in the higher age groups. Quite apart from these considerations the table of average sizes presented in the paper under discussion invalidates itself as a means of disclosing serious loss of mature fish. As it is certain that in 1932 and 1933 fish of the size dealt with in the table died in considerable numbers it is equally certain from the failure of the table to reveal their loss that this method of detection is unsound.

such positions when observation ceased in the evening. The remainder had disappeared into deep water upstream where their presence could not be detected. On the two following days the curator, Mr Claringbold, examined the trap for tagged fish, but failed to find a single specimen, and on the third day the river again rose, washing out the trap and preventing further observation. There was, consequently, no opportunity of determining how far upstream the fish travelled, but the experiment has at least shown that Lake Ellesmere trout, if allowed their liberty, will proceed upstream after being stripped and will not return within three days. The results of the experiment, therefore, agree with the statements of Armistead and Tilcombe quoted above.

With regard to the contention that egg production has remained constant in successive years the figures given on page 349 of the paper under discussion are so obviously questionable that it would be unsafe to draw any inference from them. If the year 1932 is considered, which is the only one for which particulars of both egg yield and size of fish are given, it will be found that trout stated to average 2.9 pounds in weight are credited with an average production of only 1119 eggs, which works out at approximately 385 eggs per pound of fish. In April, 1937, the present writer counted the eggs of a small but representative group of Lake Ellesmere trout which, though taken at random, had an average weight almost identical with that of the fish just referred to. The average yield of eggs per pound of fish proved low for brown trout, and the individual yields showed considerable differences which, however, appear to be attributable to differences in the sex history of the fish. The most productive specimen was approaching its first maturity while the specimen showing the lowest comparative yield had matured twice previously and revealed evidence of past ovarian injury of the kind described in the second section of this paper. It would thus appear that the low average egg yield of Lake Ellesmere trout is contributed to by the development in individuals of partial sterility consequent on injury by stripping.

The data obtained from the group are given below.

Egg Counts of Lake Ellesmere Trout.

Weight (lbs.).	Number of Eggs.
2½	1511
2¾	1979
3	2371
2¾	1445
2¾	1804
2¾	2640
4¾	2962
4	2889
Average 2.93	2200

Average number of eggs per lb. 751.

Maximum individual number per lb. 960.

Minimum individual number per lb. 587.

It will thus be seen that the average yield of eggs per fish is 2200, or nearly double the number (1119) recorded by Percival (*loc. cit.*, p. 349) as being obtained by stripping fish of approximately similar size, and that the yield per lb. of fish is 751 as compared with 385, an almost identical ratio. As the figures submitted in the paper under discussion deal with only about half of the eggs produced by Lake Ellesmere trout as they now exist, and as no attempt has been made to ascertain what becomes of the balance, they must be regarded as fractions of unknown constancy from which no deductions can be made. The most probable explanation of the difference between the egg counts and the stripping figures is that many fish

are imperfectly stripped, and, being liberated below the trap, they re-enter and are again stripped and recorded. If this is so it would appear, from the retention of so large a number of eggs as to render the fish indistinguishable as having been stripped, that, in the first instance, stripping is performed before ripeness is complete.

It is now necessary to consider the positive evidence leading up to the conclusion that the injuries were caused by stripping. The absence of injuries from immature Lake Ellesmere fish examined for comparison and from mature river-dwelling fish taken in the vicinity of the pools from which many of the injured fish were taken restricts the injuries to the class of fish handled at the traps, namely, mature lake fish. The presence of stripped fish in pools several miles above the point where the stripping trap is operated is found to be consistent with the behaviour of trout after being subjected to the unnatural process of stripping. The next consideration is that the injuries present in the specimens examined were restricted to the part of the body that is operated upon by strippers. In stripping, the lower part of the body is squeezed from the pectoral fins to the vent, that is to say, the liver, the reproductive organs, the greater part of the alimentary tract, the spleen, the mesenteries, the peritoneum and the muscular structure of the flanks are subjected to pressure. With the exception of the anterior portion of the alimentary tract these are the very structures in which injury existed. The absence of any external injuries such as scars or noticeable derangement of scales disqualifies any explanations based on the grounds of poaching or attacks by predators. Contact with poaching implements, such as spears, hoopiron or snares, if sufficiently severe to cause serious internal injuries, must leave obvious evidence in the form of external marks, and the same applies to attacks by predatory animals, such as shags and large eels. In explaining the association of internal injuries with the absence of external injury it is necessary to postulate a causative agent if a non-rigid character yet capable of exerting considerable pressure—a specification with which human hands completely agree. The further circumstances of time, place and class of fish to which the injuries were restricted leave no alternative to the conclusion that stripping was responsible, and the matter is placed beyond all question by the reproduction of the whole of the conditions described, except those that are of a secondary nature, in the manner suggested. The simple test of stripping trout with various degrees of pressure and immediately dissecting them showed that serious internal injury could be inflicted without leaving an outward mark. It was unusual to dislodge more than one or two scales. The organs that were found to be the most easily damaged are the ovaries and the liver; then come the mesenteries and the peritoneum. The spleen proved less easily damaged, by reason of its being protected to some extent by the pelvic bones,* but it was found that by exerting sufficient pressure it could be injured in the manner described without showing any outward mark on the fish. The stomach and duodenum withstood the greatest

* Further experiment suggests that while the pelvic bones protect the spleen from moderate pressure, it is actually the anterior extremities of these structures that inflict the injuries when the pressure is severe.

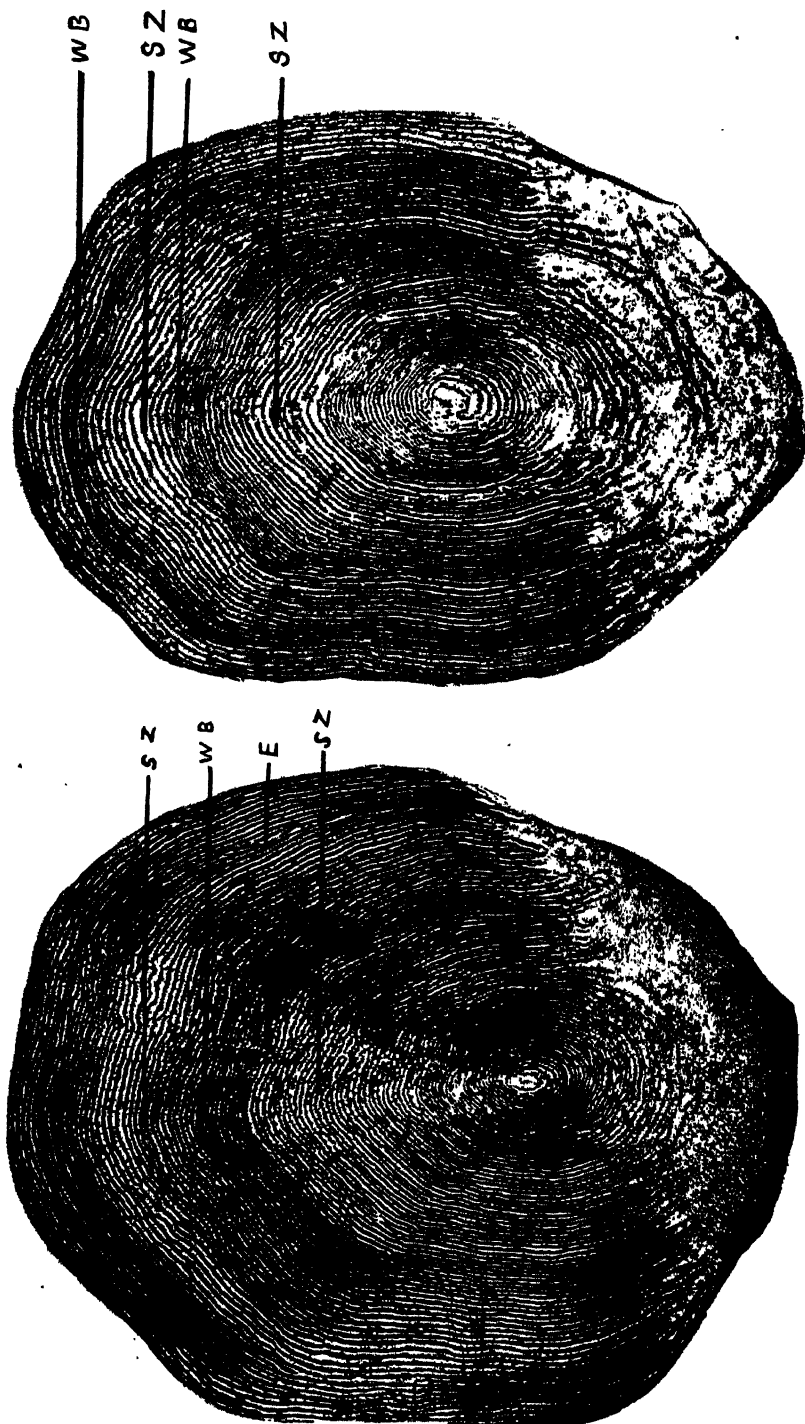


FIG. 1.—Scale of Lake Ellesmere trout showing little definition between summer zones and winter bands. S.Z.: Summer zones. W.B.: Winter bands. E.: Erosion.
FIG. 2.—Scale of river-dwelling trout showing definite summer zones and winter bands. S.Z.: Summer zones. W.B.: Winter bands.

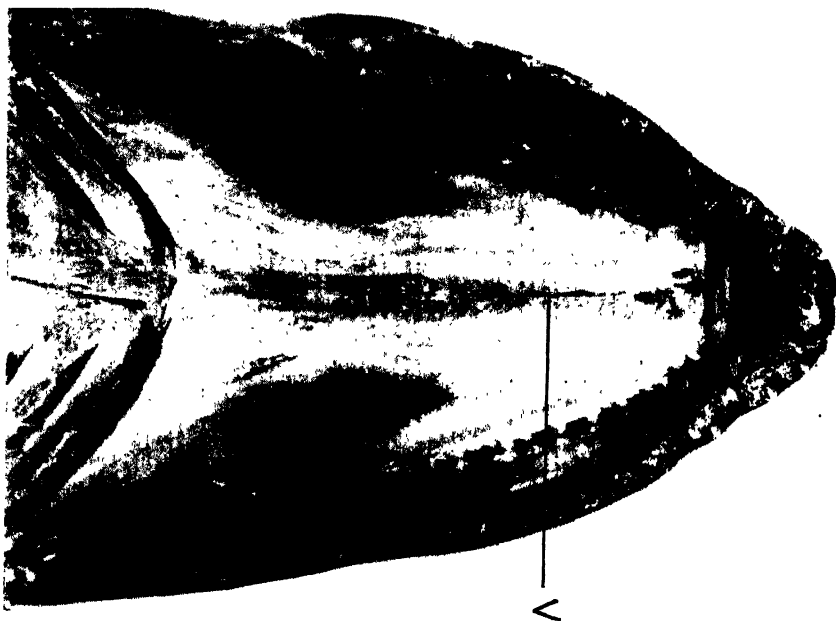


FIG. 3.—Roof of mouth of Lake Ellesmere trout showing four teeth on head of vomer, and body of vomer toothless. V.; Vomer.

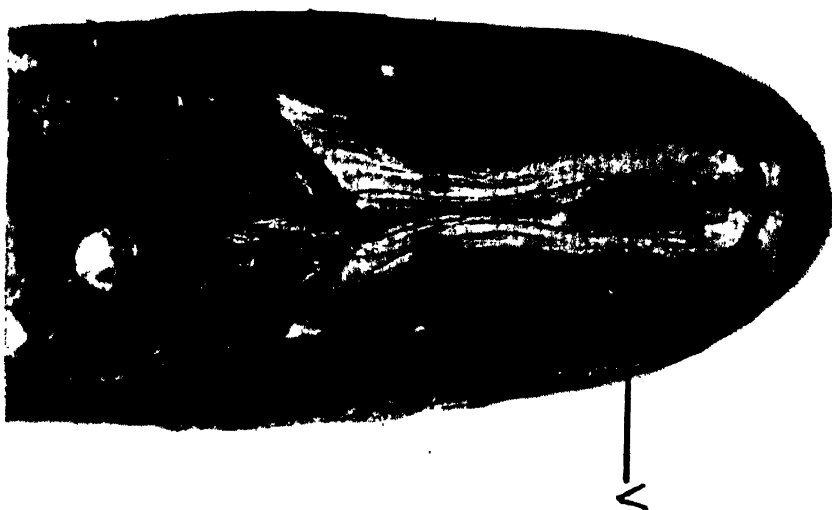


FIG. 4.—Roof of mouth of river-dwelling trout showing vomer completely armed with teeth. V.: Vomer.

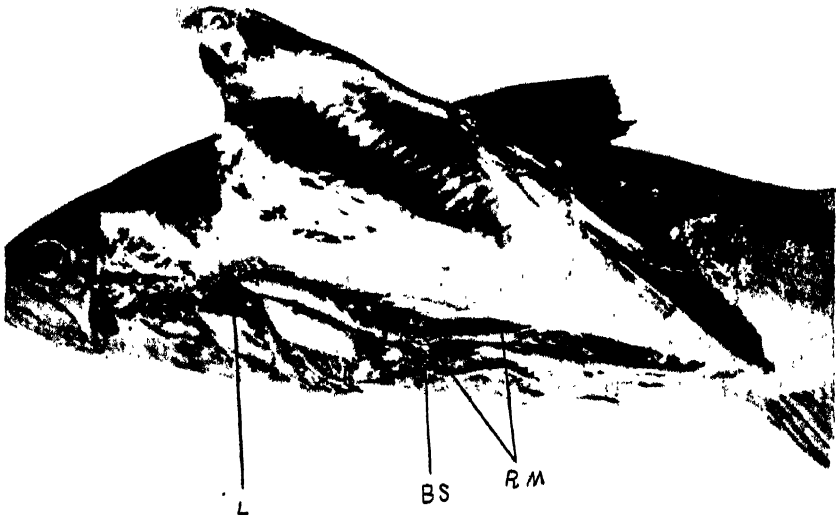


FIG. 5.—Brown trout showing injuries inflicted during routine stripping. R.M.: Rupture of upper intestinal mesentery with filamentous remnants of the structure extending across the opening. B.S.: Complete break in spleen. L.: Position of injury to liver. Injury not visible in photograph.

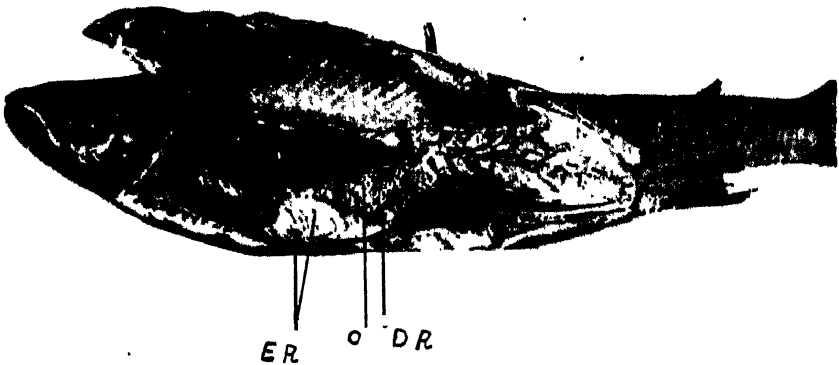


FIG. 6.—Te Anau salmon showing unnatural form of ovary resulting from injury inflicted at a previous maturity. O.: Ovary. D.R.: Diagonal rent. E.R.: Remains of eggs belonging to previous season.

pressure applied, but it was possible to damage the structure of the intestinal wall near the anus in a manner that would probably have been fatal. These results produced experimentally were found to be identical with the effects of routine stripping as carried out by official fish-culturists. The fish shown in figure 5 was killed and opened about four hours after it had been officially stripped, the only selection exercised being in the direction of securing a first spawner for the purpose of excluding any complication that might be associated with a previous maturity. Upon the body cavity being opened, evidence of serious hemorrhage was revealed, no part of the peritoneum and viscera being free from blood. Loose eggs were present in the body cavity, and there were injuries to the liver, dorsal mesentery and spleen as indicated in the caption of fig. 5. The fish had been preserved in formalin solution before being photographed.

It may finally be stated that injuries similar to those described in the second section of this paper are not restricted to brown trout but have been observed in rainbow trout from Lake Taupo and in freshwater-dwelling *Salmo salar* from Lake Te Anau, both of which are heavily trapped for stripping. A photograph of a Te Anau salmon showing the unnatural form of the ovary after recovery from moderate injury inflicted at a previous maturity is shown in fig. 6.

CONCLUSIONS.

(1) That the failure of the ill-conditioned trout present in the lower Selwyn during the spring of 1932 and of 1933 to return to the lake in the normal manner was due to their being incapacitated by internal injuries.

(2) That these injuries were caused by stripping.

(3) That the destruction of mature fish by stripping causes a serious drain on the fishery stock, and that there is no evidence that this is compensated by commensurate gain resulting from artificial culture.

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A Phase Rule Study of the System: $\text{Na}_2\text{O}-\text{V}_2\text{O}_5-\text{H}_2\text{O}$.

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SINCE vanadium occupies the next position to phosphorus in the fifth group of the Periodic Classification, in its quinquivalent state it offers certain analogies to the corresponding phosphates, their similarity frequently being emphasised by reference to the ortho, pyro and metavanadates, Na_3VO_4 , $\text{Na}_4\text{V}_2\text{O}_7$ and NaVO_3 respectively. It should not be forgotten, however, that acidification of solutions of the latter salt produces a marked yellow coloration which has been ascribed correctly to the formation in solution of a polyvanadate of the type: $\text{Na}_2\text{O}, x\text{V}_2\text{O}_5, y\text{H}_2\text{O}$, x being greater than unity, *i.e.*, the polyvanadate is richer than the meta salt in respect to the acidic radical. Unfortunately, there is no agreement as to the precise composition of this salt, at least twenty different polyvanadates having been described, with a ratio of $\text{Na}_2\text{O} : \text{V}_2\text{O}_5$, varying from 2 : 3 to 1 : 4, depending on the conditions attending their isolation. The methods employed in their preparation have almost invariably consisted in adding a weak acid to a metavanadate solution so as to buffer the solution between pH3 and pH6 and then crystallizing by evaporation. No study of this apparently complicated problem had been made on the basis of the Phase Rule and we, therefore, thought it worth while to make such an investigation. The work has been carried out during the last four years, but recently Kiehl and Manfredo (1937) have published the results of a similar investigation of the isotherm at 30° C. Publication of our results is, nevertheless, desirable because (1) in general the conclusions of the American workers are confirmed, (2) our analytical method is, we believe, superior, (3) our isotherm refers to 25° C. and (4) we come to a different conclusion with regard to the nature of the stable polyvanadate.

Method of Analysis.

Vanadium was always determined by the accurate permanganate titration of the sulphur dioxide reduced solution after removal of the excess of sulphur dioxide by carbon dioxide. Sodium was estimated as follows: Britton and Robinson (1930) have shown that the action of silver nitrate solution *in excess* on a vanadate of sodium gives a precipitate in which the ratio of $\text{Ag}_2\text{O}/\text{V}_2\text{O}_5$ is exactly that of the $\text{Na}_2\text{O}/\text{V}_2\text{O}_5$ in the original salt. Thus if a mixture of $\text{Na}_4\text{V}_2\text{O}_7$ (or $2\text{Na}_2\text{O}, \text{V}_2\text{O}_5$) and NaVO_3 (or $\text{Na}_2\text{O}, \text{V}_2\text{O}_5$) is made in such proportions that the total composition corresponds to 1.5 $\text{Na}_2\text{O}, \text{V}_2\text{O}_5$ then the first action of silver nitrate is to precipitate the less soluble silver pyrovanadate; but if the reagent is added in excess, the residual vanadate is precipitated as silver metavanadate and the composition of the whole precipitate corresponds to 1.5 $\text{Ag}_2\text{O}, \text{V}_2\text{O}_5$. The analytical method therefore consisted of adding excess of silver nitrate solution, filtering the silver vanadate precipitate, washing

with cold water, dissolution in ammonia and determination of silver by gravimetric analysis of this solution after acidification with sulphuric acid. Duplicate analyses would agree as closely as 0.02% on both Na_2O and V_2O_5 determinations. If the sample for analysis were more alkaline than the orthovanadate, standard sulphuric acid was added in known amount to bring the solution between the ortho and meta salt in composition. Similarly if the sample were more acid than the meta salt sufficient standard alkali was added to produce a colourless solution.

Equilibria with the colourless vanadates.

It will be convenient to describe first the equilibrium at 25°C . between the aqueous phase and solid phases of the colourless ortho, pyro and metavanadates. These salts were prepared by fusion of vanadium pentoxide and sodium hydroxide in different proportions and the finely ground salt was then stirred with water for a period of one to three weeks, employing a mercury seal stirrer to exclude air. The thermostat was maintained at $25^\circ \pm .01$. In some cases solid sodium hydroxide was also added to produce a more alkaline mixture. After setting, samples of the liquid phase were withdrawn by filtration through glass wool into a pipette and the solid was sampled by rapid filtration through a sintered glass filter and the "wet residue" analysed. Analyses of 30 pairs of liquid and "wet solid" phases are given as weight percentages in Table I and plotted on the usual triangular diagram in Fig. 1.

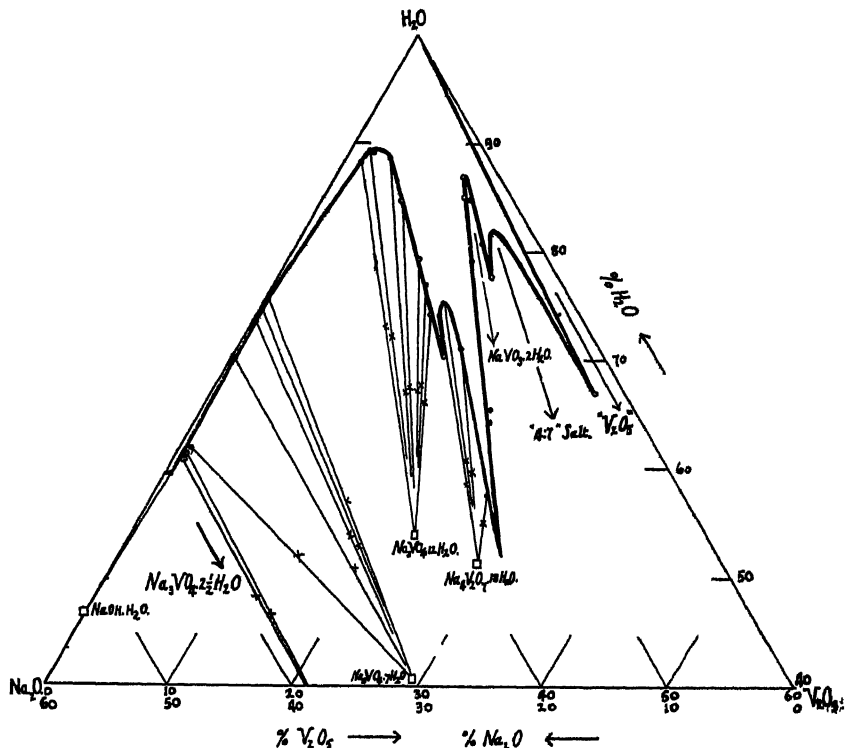


TABLE I.

THE SYSTEM $\text{Na}_2\text{O}-\text{V}_2\text{O}_5-\text{H}_2\text{O}$ AT 25°C .

Liquid Phase.		Solid Phase.		Solid.
% Na_2O	% V_2O_5	% Na_2O	% V_2O_5	
40.33	0.07	47.07	0.05	} $\text{NaOH}, \text{H}_2\text{O}$.
40.31	0.20	48.22	0.15	
40.12	0.36	49.46	0.20	
40.27	0.56	43.94	2.96	} $\text{NaOH}, \text{H}_2\text{O} + \text{Na}_3\text{VO}_4, 7\text{H}_2\text{O}$.
37.25	1.01	33.59	14.51	
35.71	—	32.82	14.20	} $\text{Na}_3\text{VO}_4, 7\text{H}_2\text{O}$.
29.63	0.21	29.41	19.79	
26.32	0.20	28.34	17.77	
25.35	0.22	28.33	19.00	} $\text{Na}_3\text{VO}_4, 12\text{H}_2\text{O}$.
24.38	0.28	27.07	16.21	
10.56	1.43	16.36	11.50	
9.26	1.41	16.26	10.96	} $\text{Na}_3\text{VO}_4, 12\text{H}_2\text{O}$.
9.12	1.87	16.16	11.40	
7.96	3.52	17.03	13.96	
9.02	6.42	17.45	15.54	} $\text{Na}_3\text{VO}_4, 12\text{H}_2\text{O} + \text{Na}_4\text{V}_2\text{O}_7, 18\text{H}_2\text{O}$.
10.13	10.58	16.64	16.21	
11.02	12.19	15.98	16.32	
11.82	14.05	16.24	17.77	} $\text{Na}_4\text{V}_2\text{O}_7, 18\text{H}_2\text{O}$.
12.80	16.97	15.20	20.53	
11.26	14.72	16.72	24.35	
10.21	14.51	15.78	23.62	} $\text{Na}_4\text{V}_2\text{O}_7, 18\text{H}_2\text{O}$.
11.16	17.80	15.79	24.26	
15.66	26.81	17.38	27.97	
12.01	23.77	12.46	24.99	} $\text{NaVO}_3, 2\text{H}_2\text{O}$.
11.57	23.62	19.76	53.26	
6.16	14.93	21.34	62.48	
2.98	10.38	12.36	37.94	} $\text{NaVO}_3, 2\text{H}_2\text{O} + \text{Polyvanadate}$.
3.41	11.70	11.65	38.57	
4.48	14.84	—	—	
4.85	16.85	—	—	

By drawing tie-lines on the triangular diagram it can be seen that at least five solid phases are stable at 25° ; in very alkaline solution $\text{NaOH}, \text{H}_2\text{O}$ is the solid phase, but the addition of a very small amount of vanadium pentoxide suffices to bring about a transition to $\text{Na}_3\text{VO}_4, 7\text{H}_2\text{O}$, a compound which is stable only in presence of an excess of alkali and which would recrystallize from its own solution as the dodecahydrate. The tie-lines are sufficient to characterize it as $\text{Na}_3\text{VO}_4, 7\text{H}_2\text{O}$, the formula given by Hall (1887), and not $\text{Na}_3\text{VO}_4, 8\text{H}_2\text{O}$ given by Baker (1885). Further addition of vanadium pentoxide leads to $\text{Na}_3\text{VO}_4, 12\text{H}_2\text{O}$, the pyrovanadate $\text{Na}_4\text{V}_2\text{O}_7, 18\text{H}_2\text{O}$ and the metavanadate $\text{NaVO}_3, 2\text{H}_2\text{O}$; the tie-lines for the last salt, not drawn in the diagram, show, in agreement with McAdam and Pierle (1912), that the dihydrate and not the anhydrous salt is stable at 25° . The diagram affords no evidence for the stable existence at 25° of the compounds $4\text{Na}_2\text{O}, \text{V}_2\text{O}_5, 26$ (or 30) H_2O obtained by Ditte (1887), $\text{Na}_3\text{VO}_4, 16\text{H}_2\text{O}$ by Roscoe (1871), $\text{Na}_3\text{VO}_4, 10\text{H}_2\text{O}$ by Baker (1885) or $\text{Na}_4\text{V}_2\text{O}_7, 8\text{H}_2\text{O}$ by Ditte (1887).

After the appearance of the paper by Kiehl and Manfredo (1937) we made a special search for the compound $\text{Na}_3\text{VO}_4, 2\frac{1}{2}\text{H}_2\text{O}$, which they found to be stable at 30° . We were able, after stirring for a month, to obtain three sets of points whose tie-lines passed approximately through the point corresponding to this compound.

The following were the analytical data obtained:—

<i>Liquid Phase.</i>		<i>Solid Phase.</i>	
% Na ₂ O		% Na ₂ O	% V ₂ O ₅
38.27		38.82	12.64
38.20		39.33	12.41
37.98		38.44	14.93

Experimental work in this region is very difficult; moreover, this hydrate is stable over only a small range of solution concentration; this makes it impossible for the tie-lines to converge on the solidus point through a large angle and hence it is not possible to locate the composition of the compound accurately. The data are, however, sufficient to show that the compound is neither the dihydrate nor the trihydrate and that the formula Na₃VO₄·2½H₂O given by Kiehl and Manfredo is likely to be correct.

Preparation of Polyvanadates.

A polyvanadate to which we give the formula 4Na₂O, 7V₂O₅, 33H₂O and which we shall refer to as the 4:7 salt, was prepared in a number of ways:—

1. By boiling an excess of vanadium pentoxide in sodium carbonate solution. The boiling should be continued for a short time only (about ten minutes), as prolonged boiling is apt to form the metavanadate; a large residue of the brown flocculent pentoxide is always left. Filtration yields a deep red solution from which efflorescent orange-red crystals are deposited on spontaneous evaporation at room temperature. Fusion of excess pentoxide with sodium carbonate gave only the colourless metavanadate.

2. After boiling an excess of pentoxide with sodium hydroxide, the filtrate on evaporation yielded mainly the metavanadate mixed with a few red crystals which analysis showed to be the 4:7 salt. Fusion with sodium hydroxide also yielded a mass which after extraction with water deposited the 4:7 salt.

3. The best method by which the 4:7 salt can be prepared is by the addition of acetic acid to a solution of sodium metavanadate, the solution being concentrated to crystallisation by evaporation *in vacuo* over sulphuric acid at room temperature. By this method large well-formed crystals can be obtained, washed free from mother-liquid and dried in a current of air. The amount of acetic acid may vary from one mol to three mols of acid per mol of sodium vanadate, but, although the same polyvanadate is formed in each case, two mols of acid give the best-formed crystals.

4. This polyvanadate has also been formed by the treatment of 1 mol. of sodium orthovanadate in solution with 2.5 mols of perchloric acid, crystallisation being effected by evaporation *in vacuo*.

5. Prepared by any of these methods the salt can be recrystallised from aqueous solution.

6. Addition of alcohol to any of these solutions precipitates a vivid yellow, apparently amorphous powder which changes over a period of days to small orange-red crystals. Analysis of the yellow powder showed that it has the same composition as the red crystals and the colour difference must, therefore, be brought about by particle size. This alcohol precipitation helps to free the salt from traces of adhering solution of sodium acetate or perchlorate.

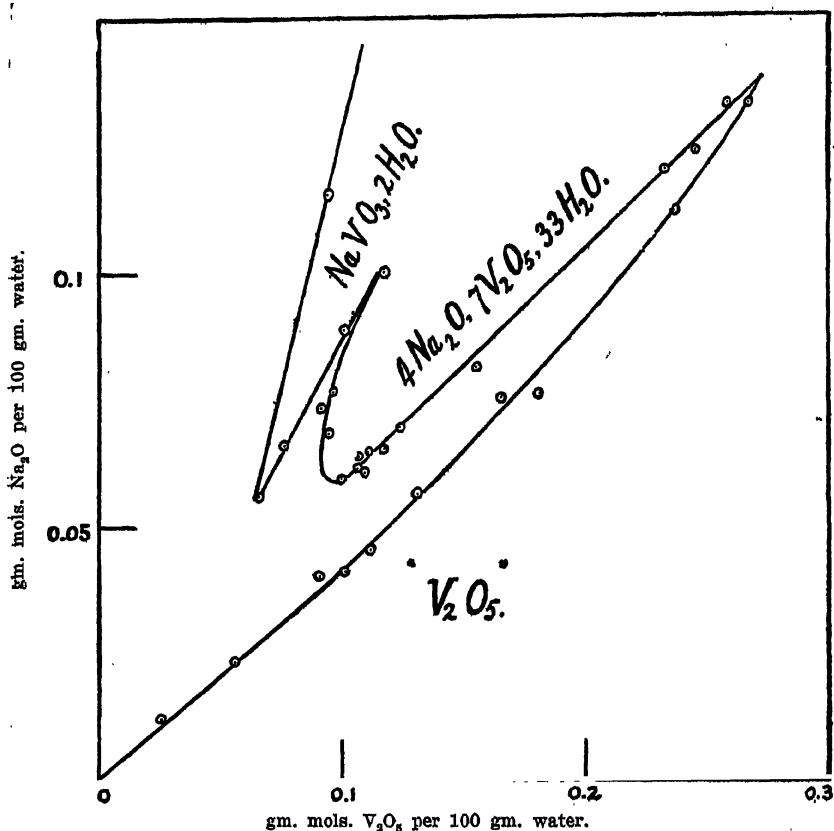
The best preparation is secured by adding two mols of acetic acid to one of sodium metavanadate, throwing down the polyvanadate by addition of alcohol and then recrystallizing from water by evaporation over sulphuric acid *in vacuo*.

Analysis of Polyvanadate.

Twenty-four analyses of this polyvanadate have been made. The percentages of Na_2O and V_2O_5 so found we do not regard as significant by themselves, because it was always difficult to determine the point at which air drying ceased to remove adhering moisture and began to cause efflorescence. The significance of the analyses can be better appreciated if they are expressed as molar ratios of $\text{Na}_2\text{O}:\text{V}_2\text{O}_5$. The following table summarizes the analyses in this form:—

Type of preparation.	No. of		Na_2O	V_2O_5
	analyses.			
Boiling with Carbonate ..	3	1	1.767	
$\text{NaVO}_3 + \text{HAc}$..	2	1	1.735	
$\text{Na}_3\text{VO}_4 + \text{HClO}_4$..	3	1	1.749	
Alcohol precipitation ..	4	1	1.754	
Recrystallisation	12	1	1.757	

The last two methods of preparation give the most reliable analyses, and it is evident that the simplest compound with this analysis would be $4\text{Na}_2\text{O}, 7\text{V}_2\text{O}_5$. Taking into consideration the appearance of the crystals before analysis, i.e., the appearance of moisture or efflorescence, we believe that the most reliable formula is $4\text{Na}_2\text{O}, 7\text{V}_2\text{O}_5, 33\text{H}_2\text{O}$ although our most reliable analyses would not be markedly inconsistent with the formulation $4\text{Na}_2\text{O}, 7\text{V}_2\text{O}_5, 34\text{H}_2\text{O}$.



An analysis of this salt by the method of Kiehl and Manfredo corresponded to $4\text{Na}_2\text{O}, 6.89\text{V}_2\text{O}_5, 34\text{H}_2\text{O}$ but we do not consider this method of analysis so reliable.

Crystallography of Polyvanadate.

We are greatly indebted to Dr. F. J. Turner for an examination of crystals of this polyvanadate. His report is as follows:—

Habit variable as a result of a tendency for crystals to be flattened parallel to any one of the three forms (*l*, *g* and *h*) of the principal zone. Two other zones (containing *l* *x* and *y*, or *l* *m* and *n* respectively) may be developed, but usually either *m* and *n* or *x* and *y* are omitted. The following angles, measured from ten different crystals, are probably correct to $\pm 5'$.

$l \wedge g$	$= 42^\circ 30'$
$g \wedge h$	$= 49^\circ 5'$
$h \wedge l'$	$= 88^\circ 25'$
$l \wedge m'$	$= 56^\circ 52'$
$m \wedge n$	$= 59^\circ 17'$
$l \wedge n$	$= 63^\circ 51'$
$a \wedge g$	$= 46^\circ 51'$
$m' \wedge g$	$= 48^\circ 30'$
$a \wedge l$	$= 56^\circ 52'$
$x \wedge y$	$= 61^\circ 25'$

Symmetry appears to be triclinic, closely approaching monoclinic (the axis of the principal zone is almost an axis of binary symmetry). Microscopically examined, the crystals are biaxial, negative, and distinctly pleochroic ($\alpha < \delta$).

Preparation of a Polyvanadate unstable at 25°.

Occasionally in the course of the above preparations the salt formed could be seen to be heterogeneous and a second polyvanadate could be separated by hand from the mass of crystals. The formation of these brownish-orange lath-like crystals was favoured by low temperature, *e.g.*, if the evaporation *in vacuo* were conducted in the ice chest. Otherwise their formation seemed to be fortuitous and not controllable, but as they could not be recrystallized from water without decomposition into pentoxide and the 4:7 salt, and no sign could be found in the subsequent phase rule investigation of their stable existence at 25°, this polyvanadate does not concern the 25° isotherm. The mean of five analyses gave to this salt the formula $\text{Na}_2\text{O}, 1.99\text{V}_2\text{O}_5, 10\text{H}_2\text{O}$. The crystallographic features, measured by Dr. F. J. Turner, are as follows:—

Habit lathy, flattened parallel to the optic axial plane. Extinction angle (δ to direction of elongation) = 23°. Distinct pleochroism (δ = orange, α = lemon-yellow, $\delta > \alpha$). Good cleavage parallel to elongation, crossed at 85° by a less perfect transverse cleavage (δ lies in the acute angle of intersection of the cleavages).

The 3:5 Polyvanadate.

We obtained a number of analyses corresponding approximately to the salt $3\text{Na}_2\text{O}, 5\text{V}_2\text{O}_5, 22\text{H}_2\text{O}$ but these were always obtained from solutions with a higher ratio of $\text{Na}_2\text{O}:\text{V}_2\text{O}_5$ under experimental conditions which excluded washing the crystals free from mother liquid. A crystallographic examination by Dr. Turner showed that they were identical with authentic crystals of the 4:7 salts and we concluded that sufficient mother liquid had been left entangled with the crystals to give a misleading analysis. We do not, therefore, claim the existence of this salt.

Equilibria with the coloured Polyvanadate.

By using different mixtures of sodium metavanadate, the 4:7 and 1:2 salts and the solution obtained by saturating sodium carbonate solution with vanadium pentoxide, it was possible to follow the equilibria between solid and saturated solutions of composition between the metavanadate and what was practically an aqueous solution of vanadium pentoxide. The last three lines of Table I refer to solutions prepared from the 4:7 salt with sodium metavanadate as solid phase. The remainder of the analyses are given in Table II.

TABLE II.

THE SYSTEM Na₂O-V₂O₅-H₂O AT 25°—(Continued).

<i>Liquid phase.</i>		<i>Solid phase.</i>		<i>Solid.</i>
%Na ₂ O	%V ₂ O ₅	%Na ₂ O	%V ₂ O ₅	
3.89	14.38	—	—	
3.75	13.78	12.42	61.95	
3.49	14.28	10.30	51.12	
3.04	14.89	10.30	56.74	
3.09	15.83	11.13	56.16	
3.21	15.76	—	—	
3.03	16.04	9.37	51.88	{ 4Na ₂ O, 7V ₂ O ₅ , 33H ₂ O
3.23	16.20	—	—	
3.24	17.13	9.68	55.59	
3.39	17.82	11.56	59.51	
3.79	21.11	10.83	52.89	
4.98	28.17	10.24	55.74	
5.04	29.34	11.14	57.25	
5.20	30.35	11.25	56.55	
5.24	31.02	10.90	58.99	
4.64	28.70	7.44	46.44	
3.42	24.03	4.30	37.11	
3.48	22.38	3.68	48.16	
2.76	18.64	10.18	51.97	
2.30	16.47	9.68	50.41	{ "V ₂ O ₅ "
2.11	15.25	—	—	
2.16	13.93	—	—	
1.29	9.07	5.90	32.88	
0.73	4.43	—	—	

A triangular diagram is not satisfactory for illustrating the equilibria in this region; tie-lines drawn on a large scale on such a diagram show that the first set of lines in the above table converge on a point but the angle subtended by the liquidus is too small to enable the composition of the solid phase to be determined with certainty. We relied therefore on the appearance of the solid phase and the analyses of the purified polyvanadate to characterise it as the 4:7 salt. A graph in which mols of Na₂O per 100 gram of solution are plotted against mols V₂O₅ per 100 grams of solution (Fig. II) shows the equilibria very clearly, giving two loops characteristic of solutions in equilibrium with the metavanadate and the polyvanadate and a third region which we have denoted "V₂O₅." On a triangular diagram the tie-lines in this region do not converge on a point, although some of them pass close to the point for the 4:7 salt, yet their non-crystalline appearance showed that they represent a different equilibrium. We conclude that those solutions are in equilibrium with vanadium pentoxide containing loosely combined adsorbed alkali.

SUMMARY.

The system $\text{Na}_2\text{O}-\text{V}_2\text{O}_5-\text{H}_2\text{O}$ can be in equilibrium at 25° with eight solid phases, viz. $\text{NaOH}, \text{H}_2\text{O}$; $\text{Na}_3\text{VO}_4, 2\frac{1}{3}\text{H}_2\text{O}$; $\text{Na}_3\text{VO}_4, 7\text{H}_2\text{O}$; $\text{Na}_3\text{VO}_4, 12\text{H}_2\text{O}$; $\text{Na}_4\text{V}_2\text{O}_7, 18\text{H}_2\text{O}$; $\text{NaVO}_3, 2\text{H}_2\text{O}$; $4\text{Na}_2\text{O}, 7\text{V}_2\text{O}_5, 33$ (or 34) H_2O ; and vanadium pentoxide containing adsorbed alkali.

Only one polyvanadate is stable at 25° and optimum conditions for its preparation are described. A second polyvanadate has been isolated and appears to be more stable at lower temperatures.

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Fishes of Otago Harbour and Adjacent Seas with Additions to Previous Records.

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INTRODUCTORY.

Scope.—Most of the following records are the result of marine studies carried out at the Marine Fisheries Investigation Station at Portobello over a period of 27 months (1930-1932), so that in spite of interruptions totalling seven months, most of the annual cycle has been covered twice; supplementary observations compiled from daily visits to the Dunedin fish market cover nearly another two years. The records refer exclusively to personal observations on specimens actually handled, so that "maximum total length," for example, means only the maximum length as measured by the author in fishes from the area studied.

The nomenclature and order of arrangement follow the list by Phillipps (1927). For the present purposes it has been thought sufficient to quote one useful reference, preferably one with a figure. Although the scope of the work is not taxonomic, it is clear that much work remains to be done in this branch of ichthyology; Phillipps, for example, collects 306 species in his bibliography, a surprisingly short number in comparison with the 2150 species listed from Australia a decade ago. Natal, Fiji and Samoa have considerably more species than are known from New Zealand. The species obtained within the short period of study include sufficient novelties to suggest that further work would add considerably to the New Zealand list.

Vernacular names.—A brief contact with the commercial handling of fish is sufficient to reveal a regrettable and confusing lack of uniformity in the vernacular names, which nevertheless must be recognised as of importance, because, although they lack the standing and international recognition accorded to taxonomic names, are the names that are used in the industry and under which valuable commodities are sold. Any step towards uniform and correct usage is a gain, and the suggestion may be offered that this could be accomplished by a considered selection of names by an authorised body and their adoption in a publication on fishes and fisheries, designed to attract those engaged in commercial and recreational fishing as well as naturalists, tourists and others.

1. *Heptatretus cirrhatus* (Bloch and Schneider).

Hagfish (slime-eel, hag, slimy, borer). *Tuere*.

Waite, 1909, p. 132, pl. xiii.

Localities: Everywhere in and around Otago Harbour, 1-120 fathoms, over any type of bottom.

Frequency: Occasional, sporadic; one fisherman claimed to have taken 9 in one day, but this exceeds the average; at times no specimens may be seen for months. Taken in nets or with line and bait.

Size.—Maximum total length 27 ins., average 24 ins.

2. *Geotria australis* Gray.

Lamprey. *Korokoro*.

Hutton, 1872b, p. 272, pl. xii, figs. 139 and 139a.

A 19-inch specimen was ejected from the stomach of a ling caught in 20 fathoms off Wickliffe Bay. Occasional specimens seen on the market among warehou; these infrequent specimens, taken in the seine net only when the mesh is clogged with weed and mud, contrast with the former abundance both inside and outside the harbour.

3. *Notorhynchus pectorosus* (Garman).

Seven-gilled shark.

McCoy, 1880, 1, p. 16, pl. xliii, fig. 2.

One specimen, total length 54 ins., hooked off Cape Saunders 27/7/33.

4. *Galeorhinus australis* Macleay.

Southern tope.

Phillips, 1924a, p. 260, fig. 2.

Two 17½ ins. specimens were taken from the stomach of a porbeagle shark. A 72 ins. specimen, caught June, 1933, was seen on the market.

5. *Mustelus antarcticus* Guenther.

Smooth-hound (gummy, dogfish).

McCulloch, 1909, p. 315, pl. xc, fig. 3.

Localities: Everywhere, surface to 120 fathoms; occurring indifferently over any type of bottom, including sand, rock and mud and on the outside reefs.

Frequency: Very abundant, though much less plentiful than formerly; in the harbour and in the shallow trawling grounds and proper grounds. A marked decrease was noticed during the years 1930-31-32.

Size: Maximum total length 40 ins., average 34 ins.

6. *Cephaloscyllium sabella* (Broussonet).

Carpet shark (ground shark).

Waite, 1909a, p. 136, pl. xiv, fig. 1, and pl. xxi, fig. 1.

Localities: On rock, sand or shell bottoms, especially in the vicinity of reefs; favoured localities are Cape Saunders, The Kaik, North Reef, and especially Brinn's Point; exclusively benthic; hooked in 120 fathoms at North Reef.

Frequency: Common, though rare in the harbour or away from the reefs.

Size: Maximum total length 8 ft., average 3 ft.

7. *Alopias vulpinus* (Bonnaterre).

Thresher shark.

Phillipps, 1924a, p. 265, fig. 9.

Localities: 5–80 fathoms outside the harbour.

Frequency: One to three each year, others often seen.

Size: Maximum total length 18 ft., average 10 ft.

8. *Lamna nasus* (Bonnaterre.)

Porbeagle shark (moki shark).

Phillipps, 1924a, p. 267, fig. 2.

Localities: Fairly common outside the Otago Heads, chiefly at North Reef, South Reef and The Rock; 50–120 fathoms.

Size: Maximum total length 9 ft., average 3 ft. 6 ins.

9. *Squalus fernandinus* Molina.Spined dogfish. *Okeoke*.

Waite, 1921, p. 23, fig. 30.

Localities: Common everywhere inside and outside the harbour, subject to migrations; surface to 135 fathoms (North Reef).

Frequency: Very abundant, decidedly more so than formerly.

Size: Maximum total length 38 ins.; males smaller, maximum 32 ins., average 24 ins.

10. *Typhonarke aysoni* (Hamilton).

Blind numbfish.

Waite, 1909a, p. 146, pl. xviii.

Localities: Off Otago Heads and The Brothers in 28 fathoms.

Frequency: Once considered rare, now common off The Brothers rocks when from 18 to 20 may be caught while trawling.

Size: Off Otago Heads, maximum total width 36 ins.; off The Brothers range from 9 ins. to 15 ins.

11. *Raja nasuta* Mueller and Henle.Skate. *Whai*.

Waite, 1909a, p. 148, pls. xix and xxi, fig. 2.

Localities: Inside and outside the harbour 1–100 fathoms, commonest N.E. Otago Heads and in Blueskin Bay, 10–19 fathoms, sandy bottoms.

Frequency: Abundant; 1931 present at times in such quantities as to prevent the trawl of the station launch being hauled aboard.

Size: Maximum total length 5 ft., average 3 ft.; males smaller than females.

12. *Callorhynchus millii* Bory.Elephant-fish. *Reperepe*.

Waite, 1921, p. 35, fig. 49.

Localities: Chiefly outside the Heads in 20–30 fathoms, also in 5–15 fathoms Blueskin Bay; at times entering the harbour.

Frequency: Abundant, forming schools in the upper levels at least, sometimes taken singly in deep water. From November to March large hauls are made in Blueskin Bay in the comparatively shallow depths mentioned. Formerly plentiful in the harbour, latterly only occasional small runs have occurred and the fish have not stayed long.

Size: Maximum total length 42 ins., minimum 9 ins., average 28 ins.

13. *Sardinia neopilcharda* Steindacher.Pilchard. *Mohimohi*.

Waite, 1921, p. 37, fig. 53.

Localities: Offshore and at times close inshore in immense surface shoals during summer and autumn, from Waikawa to Oamaru.

Frequency: The numbers of this prolific migratory fish, though showing a decided falling-off, can be described only in superlatives. Large shoals were observed during 1930-32 at Cape Saunders; 10 miles off Papanui Inlet; in mid-harbour in fair numbers; caught in seine net with garfish bunt in three localities in the harbour. Many stranded in 1932 but not utilised.

Size: Maximum total length 5 ins., average 3 ins.

14. *Clupea antipodum* (Hector).Sprat. *Kupae*.

Arthur, 1882, p. 203. pl. xxxiv.

Localities: Similar to that of pilchards.

Frequency: Not as frequently seen as pilchards, nor in such numbers.

Size: Maximum total length 8½ ins.

15. *Gonorynchus gonorynchus* (Linnaeus).

Sand-fish (sand eel).

Waite, 1904, p. 146, pl. xvii, fig. 3.

Localities: Throughout the harbour, on outside beaches, at Taieri Mouth on sandy bottoms.

Frequency.—Often seen, but not abundant. Taken in seine nets, especially with a garfish bunt.

Size: Maximum total length 24 ins., average 17 ins.

16. *Galaxias fasciatus* Gray.*Kokopu*.

Hutton, 1872a, p. 59, pl. x, fig. 94.

A large specimen 15 ins. long was caught at Waitati Bay and kept in seawater for several days. Common in creeks running into the harbour.

17. *Galaxias attenuatus* (Jenyns).Minnow, whitebait. *Hiwi, inanga*.

Phillipps, 1924b, p. 119, with fig.

Localities: The only marine record is that of a number of specimens 3½ ins. in length caught in a garfish bunt in the Otago Harbour in February, 1931.

18. *Argentina elongata* Hutton.

Silverside (snodgall).

Waite, 1911, p. 161, pl. xxiv.

Localities: Inside and outside the harbour, mainly in tidal areas; taken on hook, more commonly in seine nets.

Frequency: Common, much less so than formerly.

Size: Maximum total length 18 ins., average 12 ins.

19. *Retropinna retropinna* (Richardson).Smelt. *Paraki*.

Richardson, 1846, p. 121, pl. lii. figs. 1-3.

Localities and Frequency: Abundant in the harbour during summer and autumn; taken in garfish bunt of clogged seine nets in Winton's and Kinnard's Beaches and Cockle Bank. Enormous numbers are seen escaping through the meshes when a seine net is being hauled in.

20. *Anguilla aucklandii* Richardson.

Long-finned eel. *Tuna*.

Richardson, 1846, p. 113, pl. xlv, figs. 7-13.

The only specimen of this species was one taken off Kuri Bush (Taieri County), October, 1933, in 30 fathoms.

Size: Weight 10 lbs.

21. *Anguilla australis* Richardson.

Short-finned eel.

Waite, 1921, p. 48, fig. 72.

A 27-inch specimen was washed ashore during a gale in the harbour (30/6/30). Two specimens each weighing 10 lbs. were caught off Kuri Bush, October, 1933.

22. *Leptocephalus conger* (Linnaeus).

Conger eel. *Koiro*.

Hutton, 1872a, p. 66, pl. xl, fig. 105.

Localities: Inside and outside the harbour, especially at Brinn's Point; a ground fish, taken in depths to 120 fathoms and in the harbour in clogged seine nets.

Frequency: Solitary, infrequent, maximum 2-3 per line per day.

Size: Maximum total length 80 ins., average 34 ins.

23. *Muraenichthys breviceps* Guenther.

Griffin, 1921, p. 351, pl. liv, fig. 1.

A specimen was washed ashore at Portobello, June, 1937; this is the first record south of Nelson.

Size: 18½ ins.

24. *Centriscops humerosus* (Richardson).

Bellows-fish.

Waite, 1911, p. 170, pl. xxvi.

Localities: Outside Otago Heads, 20-23 fathoms.

Frequency: Six specimens seen by the author.

Size: Maximum total length 5½ ins.

25. *Syngnathus blainvillianus* Eydoux and Gervais.

Short-snouted pipefish.

Waite, 1911, p. 174, pl. xxvii, fig. 2.

Localities: Among weed in rocky localities, chiefly in the harbour.

Frequency: Common in the harbour throughout the year; less common outside the harbour. Hundreds washed ashore after a gale (30/6/30).

Size: Maximum total length 5 ins., average 4 ins.

26. *Syngnathus norae* Waite.

Long-snouted pipefish.

Waite, 1911, p. 137, pl. xxvii, fig. 1.

Localities: Blueskin Bay; 7 miles off Otago Heads and in 80 fathoms.

Frequency: Occasionally seen; rather rare in the harbour.

Size: Maximum $16\frac{1}{4}$ ins., average 10 ins.**27. *Hippocampus abdominalis* Lesson.**

Seahorse.

Waite, 1921, p. 60, fig. 92.

Localities: Everywhere among seaweed, surface to at least 23 fathoms. In the harbour, clinging to set nets or among weed.

Size: Maximum $8\frac{1}{2}$ ins., average 5 ins.**28. *Hemirhamphus intermedius* Cantor.**

Garfish (piper).

Roughley, 1916, p. 27, pl. iv.

Localities: In and without the harbour, surface to at least 22 fathoms; on *Zostera* flats in the harbour.

Frequency: Very abundant. In fine weather from 400 to 1000 dozen may be taken in the harbour with a seine net provided with a garfish bunt.

Size: Maximum total length 26 ins., average 16 ins.

29. *Coelorhynchus australis* (Richardson).

Javelin-fish (rat-tail).

Waite, 1911, p. 177, pl. xxix, fig. 1.

Localities.—One specimen, from the stomach of a bass groper in 20 fathoms.

Size: 23 ins., exceeding by nearly two ins. the largest recorded by Waite.

30. *Macrurorus novae-zelandiae* (Hector).Whip-tail. *Hoki*.

Waite, 1911, p. 180, pl. xxx, fig. 1.

Localities: Prior to 1933 known to author only from stomachs of groper and bass groper, except one specimen from the Nuggets; since then one specimen off Otago Heads (18/5/33) and three others. same locality (24/5/34).

Size: Maximum total length 50 ins., minimum 11 ins.

31. *Merluccius gayi* (Guichenot).

Hake (whiting).

Waite, 1911, p. 182, pl. xxx, fig. 2.

Localities: Chiefly in 20-30 fathoms offshore localities; best grounds 3-7 miles from Otago Heads. Occasionally in the harbour and Blueskin Bay and Taieri Mouth.

Frequency: Never plentiful inshore, numbers offshore somewhat problematical.

Size: Maximum total length 48 ins. Maximum secured by Waite (*l.c.*, p. 183) was only 33 ins.Vernacular: The name whiting, though more properly reserved for *Gadus*, is firmly rooted in Otago and Canterbury. *Merluccius* in England and America is called hake.

32. *Physiculus bacchus* (Bloch and Schneider).Red cod. *Hoka*.

Waite, 1911, p. 183, pl. xxxi, fig. 1.

Localities: Everywhere, surface to 120 fathoms, occurring on sand, shell, pebbles, cockle banks, reefs, and even mud. Taken on the hook, in trawl, seine and set nets.

Frequency: Excessively abundant. Red cod are active, wandering fish living at almost any level—at the bottom or surface or any intermediate depth.

Size: Maximum total length 30 ins., average 22 ins.

33. *Lotella rachinus* (Forster).

Rock cod.

Phillipps, 1926, p. 532, pl. 89.

Localities: Inside and outside the harbour at Brinn's Point, Nuggets, Taieri Mouth and intermediate locations; in the harbour, but never far away from weed.

Frequency: Only occasional specimens seen.

Size: Maximum total length at Cape Saunders 17 ins., in the harbour 10 ins.

34. *Pseudophycis breviusculus* Richardson.

Bastard red cod.

Hutton, 1872a, p. 47, pl. viii, fig. 76.

Status: The last census in which specific status is allowed for this fish is that by Hutton (1904, p. 47); it was united by Waite (1907, p. 18) with *Physiculus bacchus* Forster, this decision being followed by Phillipps, (1927, p. 23), but it now appears that reinstatement is necessary. The chief characters by which the two may be distinguished are as follows:—

Br. 7, D. 8/46, A. 50.

Maxillary not reaching hinder border of eye. Teeth villiform, equal in size forming bands in both jaws. Ventrals exceedingly narrow styliform base with anterior insertion at the throat. Colour brownish, vertical fins with dark edges. No spot on pectoral. *P. breviusculus*

Br. 7, D. 10/42, A. 40.

Maxillary reaching to or beyond the hinder border of the eye. Ventrals with a broader and flattened base; a dark blotch on base of pectoral *P. bacchus*

This verdict accords well with the description and figure of the former species by Hutton (1872a, p. 47, pl. 8, fig. 76), and of the latter by Waite (1911, p. 183, pl. 31, fig. 1), and may be further supported as follows:—The pectoral formula for *P. breviusculus* is P. 19, that for *P. bacchus* is P. 23.

Localities: Deep water, 30 fathoms at least, always amongst rock and weed, never in the harbour. Cape Saunders and Taieri Mouth.

Frequency: Sometimes not seen for months, solitary, not common.

Size: Maximum total length 25 ins.

35. *Auchenoceros punctatus* (Hutton).

Ahuru.

Guenther, 1869, p. 26, pl. iii, fig. C.

Localities: Within and without the harbour in shallow water.
First record south of Timaru (Waite, 1911, p. 185).

Frequency: Abundant, but frequently difficult to define because of spasmodic records tending to suggest an increase in numbers during the period of observation.

Size: Maximum total length 5 ins., average 4 in., minimum 2 ins.

36. *Trachichthodes affinis* (Guenther).

Golden snapper.

McCulloch, 1934, p. 35, pl. xii, fig. 117a.

Localities: One specimen, North Reef, 100 fathoms; first record south of Cape Campbell (Phillipps, 1921, p. 121).

Size: Total length 15 ins.; weight 2 lbs.

37. *Paratrachichthys trailii* (Hutton).

Roughy.

Waite, 1921, p. 73, fig. 3.

Localities: A specimen stranded at Lower Portobello, June, 1931; another, trawled off Otago Heads on May 30, 1934, is the first specimen to have been taken alive in New Zealand waters.

Size: Total lengths 7 ins. and 6 ins. Colour bright crimson; after death orange.

38. *Zeus faber* Linnaeus.

John Dory.

Roughley, 1916, p. 168, pl. lviii.

Localities: 23 fathoms off Otago Heads.

Frequency: Maximum number in one year, 3 specimens.

Size: Maximum total length 22 ins.; weight 5½ lbs.

39. *Cyttus australis* Richardson.

Boarfish.

Waite, 1921, p. 75, fig. 114.

Localities: Two specimens trawled off Otago Heads, 1930 and 1932.

Size: Maximum total length 10 ins.

40. *Cyttus novae-zealandiae* (Arthur).

Silver Dory.

Waite, 1911, p. 190, pl. xxxii.

Localities: Outside the harbour, 17 to 23 fathoms.

Frequency.—Occasionally seen, six specimens caught from June to September, 1932, and 24 others received by the author in 1933. Now less rare than formerly.

Size: Maximum total length with snout extended 9 ins., normal length 7½ ins.

41. *Rhombocyttus traversi* (Hutton).

Hutton, 1872b, p. 261, pl. ix.

Localities: The only specimen examined, now in Otago Museum, was caught at Purakanui, January, 1933.

Size: Total length 1½ ins., depth 1½ ins.

42. *Trachipterus trachipterus* (Gmelin).

Ribbon-fish.

McCoy, 1886, pl. cxxii.

Localities: One specimen trawled off Otago Heads in 23 fathoms.

Size: 20 ins.

43. *Caulopsetta scapha* (Forster).

Witch (megrim).

Waite, 1911, p. 200, pl. xxxiv.

Localities: Outside the heads in from 4–24 fathoms; no doubt also at greater depths.

Frequency: Nowhere plentiful, but commonest off Otago Heads in 16–24 fathoms, where 6–10 are taken in one trawl.

Size: Maximum total length 16½ ins.

44. *Colistium nudipinnis* Waite.

Turbot

Waite, 1911, p. 209, pl. xxxix.

Localities: Taken by trawl along the coast north and south of Otago Heads; not seen inside the harbour.

Frequency: Abundant from June to December and on the market on an average of twice a week.

Size: Maximum total length 30 ins.

45. *Colistium guntheri* Hutton.

Brill.

Waite, 1911, p. 211, pl. xl.

Localities: Commonest off Wickliffe Bay in 17 fathoms.

Frequency: Less common than flounders, more so than turbot. A dozen a day is a good average, but occasionally a trawler will secure a case. Seen on the market almost every day of the year.

Size: Maximum total length 36 ins.; weight 15 lbs.

46. *Rhombosolea plebeia* (Richardson).

Sand flounder.

Waite, 1911, p. 203, pl. xxxv.

Localities: Inside and outside the harbour; extreme high water level to at least 63 fathoms, commonest in 19–23 fathoms; benthic, in sand or sandy mud and shelly bottoms.

Frequency: Much the commonest species of flounder, but less abundant than formerly.

47. *Rhombosolea leporina* Guenther.

Yellow flounder (yellowbelly).

Waite, 1911, p. 205, pl. xxxvii.

Localities: Chiefly in rivers or at their mouths, also less commonly in 3–10 fathoms off Wickliffe Bay, Purakanui, etc.; and in 16 fathoms north-east of the Heads; also in the harbour.

Frequency: Common; in the harbour they may disappear for months and then reappear. It is not uncommon for five or six dozen to be taken in one haul at Taieri Mouth.

Size: Maximum total length 15 ins., average 11 ins.

48. *Rhombosolea tapirina* Guenther.

Green-back flounder.

Waite, 1911, p. 204, pl. xxxvi.

Localities: Outside and especially inside the harbour; favoured outside localities Kaikai Beach, near Hayward's Point, 2-5 fathoms, and north-east of Heads and off Wickliffe Bay in 19 fathoms.

Frequency: Common in the harbour in the autumn and outside in August.

Size: Maximum total length 20 ins.

49. *Rhombosolea retiaris* Hutton.

River flounder (black flounder).

Waite, 1911, p. 207, pl. xxxviii.

Localities: Chiefly in rivers, also fairly common outside the harbour and occasionally within. Two or three may be seen daily over a considerable period amongst other flatfish caught from 7-22 fathoms off Otago Heads, then they may not appear for weeks.

50. *Peltorhamphus novae-zelandiae* Guenther.

Common sole.

Waite, 1911, p. 213, pl. xlii.

Localities: Almost exclusively outside the harbour.

Frequency: Abundant.

Size: Maximum total length 30 ins.

51. *Pelotretus flavilatus* Waite.

Lemon Sole.

Waite, 1911, p. 212, pl. xli.

Localities: As for the previous species, but rarer in the harbour.

Frequency: In the aggregate, lemon soles must be rated as very common.

Size: Maximum total length 22 ins.

52. *Agonostomus forsteri* (Cuv. and Val.).

Yellow-eyed mullet.

Waite, 1921, p. 83, fig. 126.

Localities: Everywhere in bays, rivers, creeks and lagoons inside and outside throughout the year; gregarious, forming extensive compact shoals; on bottoms of sand or gravel and around tidal flats.

Frequency: Abundant, the supply exceeding the demand.

Size: Maximum total length 20 ins., average 11 ins.

53. *Serirolella punctata* (Forster).

Silver-fish.

Waite, 1911, p. 231, pl. li.

Localities: Only four specimens seen, and these in 1932, in May, June, and July. Sent to Dunedin and Auckland Museums.

Size: Maximum total length 14 ins., minimum 11 ins.

54. *Seriolella brama* (Guenther).

Warehou.

Waite, 1911, p. 229, pl. 1.

Vernacular: It is to be hoped that the misnomer "trevally" for sizes up to 14 ins. will continue to be replaced by the name warehou.

Localities: More numerous round Otago Heads than to the north or south; in large shoals, surface to 19 fathoms, commonest in bays and sandy beaches from 0-6 fathoms. The vagaries in the depths in which they are found depend on the food supplies.

Frequency: Abundant; the shoals are large and dense. Supply is more than sufficient for the demand.

Size: Maximum 16 ins., average 11 ins.; former maximum 24 ins.

55. *Seriolella porosa* Guichenot.

Silver warehou.

Hutton, 1876, p. 211.

Localities: North Reef in 150 fathoms (March, 1932). Hitherto unknown from Otago and unrepresented in the collections of the Otago and Auckland Museums, where the only specimens have been deposited.

Size: Maximum total length 26 ins.

56. *Hyperoglyphe porosa* (Richardson).

Bream.

Waite, 1921, p. 86, fig. 131.

Localities: North and South Reefs and The Rock, 30-150 fathoms, and one record from Taieri Mouth, 40 fathoms. Confined to rocky bottoms.

Frequency: Now common enough to fill 20 cases in one's day's fishing.

Size: Maximum $4\frac{1}{2}$ ft.; weight 80 lbs..

57. *Polyprion americanus* (Bloch and Sehn.).

Bass groper.

Waite, 1913, p. 215, pls. v and vi.

Localities: North and South Reefs, not known from The Rock; 120-200 fathoms.

Frequency: Common, especially in July and August, November and December.

Size: Maximum total length 5 ft.; weight 100 lbs.

58. *Polyprion oxygeneios* (Bloch and Sehn.).

Groper. *Hapuka.*

Waite, 1911, p. 215, pl. xliii.

Localities: Chiefly at North and South Reefs and at The Rock during the winter and spring; caught by trawlers during summer and autumn.

Frequency: The decline in recent years is a matter of major importance. Formerly abundant and caught anywhere outside the Otago Heads. The decline is serious and the cause undoubtedly the uncontrolled fishing in the spawning season.

Size: Average 10 lbs. weight; formerly 25 lbs. was the average.

59. *Hypoplectrodes semicinctus* (Cuv. and Val.).

Half-banded sea perch.

Hector, 1875, p. 240, pl. x, fig. 1.

Localities: Three specimens only from the North Reef in 100 fathoms.

Size: Maximum total length 16 ins.; two measured 12 ins.

60. *Caesioperca lepidoptera* (Forster).

Red perch.

Roughley, 1916, p. 75, pl. xxi.

A 12-inch specimen caught off Akaroa in 30 fathoms (29/11/33) considerably extends the southward range of the species.

61. *Usacaranx lutescens* (Richardson).

Trevally (school trevally).

Griffin, 1932, p. 129, pl. xxi.

Two 22-inch specimens caught off Cape Saunders by trawler in July, 1935, appear to provide the first reliable record from Otago.

62. *Trachurus novae-zelandiae* Richardson.

Horse mackerel.

McCoy, 1878, p. 25, pl. xviii.

Localities: Inside and outside the harbour, surface to 20 fathoms.

Frequency: Common; more so formerly.

Size: Maximum 20 ins.

63. *Regificola grandis* (Castlenau).

Yellowtail (Otago), kingfish (Auckland).

Griffin, 1932, p. 133, pl. 24.

Localities: North Reef, 85 fathoms; not nowadays inside the harbour.

Frequency: Occasional specimens seen on the market.

Size: Maximum total length 51 ins.; weight 44 lbs.; former maximum 60 ins.

64. *Arripis trutta* (Forster).

Kahawai.

Roughley, 1916, p. 117, pl. xxxii.

Localities: Large surface shoals, usually inshore, entering the harbour in summer; also less abundant in deep water, e.g., The Rock (50 fathoms) and off Otago Heads on sandy bottoms.

Frequency: Abundant when present, the shoals are large, but less numerous than formerly. The reason for the decline is obscure, but decidedly not overfishing.

Size: Maximum total length 29 ins.; weight 9 lbs.

65. *Brama raii* (Bloch).

Ray's bream.

McCoy, 1887, p. 127, pl. cxxxiii.

Localities: One specimen North Reef, 130 fathoms (2/11/35). Not previously recorded south of Queen Charlotte Sound.

Size: 23 ins.; weight 4 lbs.

66. *Pagrosomus auratus* (Forster).

Snapper.

Roughley, 1916, p. 130, pl. xliii.

Localities: Blueskin Bay, North Reef, Tairoa Heads, Taieri Mouth, 6–22 fathoms.

Frequency: One or two per week are taken by trawlers throughout the year.

Size: Maximum total length 31 ins.; weight 16 lbs.

67. *Pseudopentaceros richardsonii* (Smith).

McCulloch and Phillipps, 1923, p. 18, pl. iv. fig. 1.

Localities.—One specimen from 5 fathoms, Otago Heads; not known previously south of Nelson.

Size: Maximum total length 16 ins.; weight 13½ lbs.

68. *Haplodactylus meandratus* (Richardson).

Marble-fish (granite trout).

Haast, 1873, p. 272, pl. xvi.

Localities: Among weed-covered rocks; commonest at Brinn's Point, Purakanui, Moeraki, Hunter's Point, Shag Point, and many parts of the harbour, 4–20 fathoms.

Frequency: Not abundant; they have declined in recent years.

Size: Maximum 3 lbs.

69. *Dactylopagrus macropterus* (Forster).*Tarakahi.*

Waite, 1911, p. 220, pl. xlv.

Localities: Everywhere outside the harbour, 5–100 fathoms; small ones inside the harbour. On all bottoms, preferably rough gravelly bottoms.

Frequency: Common, but less abundant than formerly.

Size: Maximum total length 28 ins.; weight 9 lbs.; former maximum 42 ins.

70. *Chironemus spectabilis* Hutton.

Red moki.

Hutton, 1873, p. 259, pl. vii.

One specimen caught off Otago Heads (24/8/33), length 10 ins. Rare south of Bay of Plenty.

71. *Mendosoma lineatum* Guichenot.

Hutton, 1873, p. 260, pl. vii.

One specimen off Harrington Point (20/11/33); hitherto known only from Cook Strait and Milford Sound.

72. *Latridopsis ciliaris* (Forster).*Moki.*

Richardson, 1846, p. 37, pl. xxxvi, figs. 6–7.

Localities: Mainly inshore near rocks and kelp, also frequently trawled in 10–30 fathoms, migrating into the harbour in October and leaving again on the approach of cold or dirty water.

Frequency: Less plentiful than formerly, but still taken with set nets. In 20 fathoms they form shoals and tend to keep moving, as shown by their abundance and absence in successive trawls.

Size: Maximum total length 42 ins.; weight 19 lbs.

73. *Latris lineata* (Forster).

Trumpeter.

McCulloch, 1934, p. 94, pl. xxix, fig. 249a.

Localities: On or near rocky bottoms, never on sand; 50–135 fathoms; inshore to 23 fathoms (Pudding Stone, Cape Saunders) in summer only. Main localities North and South Reefs, The Rock, Cape Saunders, Two Lights, Gull Rocks, at times Harrington Point and Brinn's Point.

Frequency: Not uncommon, especially towards the south, but much less abundant than formerly; not seen in the harbour now.

Size: Maximum total length 42 ins.; weight 60 lbs.

74. *Latris forsteri* Castlenau.

Bastard trumpeter.

McCulloch, 1934, p. 68, pl. xxix, fig. 250a.

One specimen off Otago Heads (27/6/35); first record for New Zealand. Length 26 ins.

75. *Odax vittatus* Richardson.Kelp-fish. *Tarao*.

Arthur, 1884, p. 169, pl. xiv, fig. 7.

Four harbour specimens examined; maximum total length 9½ ins.

76. *Coriododax pullus* (Forster).

Greenbone (butterfish, kelp-fish, kelp-salmon).

Waite, 1911, p. 227, pl. xlix.

Localities: Outside the harbour, 1–25 fathoms, near weed or rocks; inside at irregular intervals during warm weather; otherwise not migratory.

Frequency: Decidedly less numerous than formerly, seen about once a week during October to March on the market.

Size: Maximum 24 ins.; weight 6 lbs.

77. *Pseudolabrus coccineus* (Bloch and Schn.).

Scarlet parrot-fish.

Waite, 1911, p. 224, pl. xli.

Localities: Frequently seen up and down the coast, especially from Taieri Mouth to Brinn's Point in the north. A bottom fish.

Size: Maximum 18 ins.; weight 5 lbs.; average 12 ins.

78. *Pseudolabrus celidotus* (Forster).

Spotty.

Waite, 1921, p. 129, fig. 195.

Localities: Everywhere there is shelter among rocks or weed; low water to 4 fathoms; also 4–23 fathoms off Otago Heads, 50 fathoms at The Rock, 80 fathoms at North and South Reefs. Exclusively benthic.

Frequency: Very common.

Size: Maximum 1½ lbs.

79. *Pseudolabrus cinctus* (Hutton).

Girdled parrot-fish.

Waite, 1911, p. 266, pl. xlvii.

Localities: Occasionally specimens inside the harbour at Harrington Point, also at Brinn's Point, Cape Saunders, The Rock and Taieri Mouth, on rocky bottoms, 0–50 fathoms.

Frequency: Moderately common.

Size: Maximum total length 18 ins.; weight 4 lbs.

80. *Pseudolabrus pittensis* (Waite).

Banded parrot-fish.

Waite, 1911, p. 226.

Localities: North and South of Otago Heads, Moeraki to Cape Saunders; occasionally inside the harbour at Harrington Point. Depths 4–50 fathoms, on rocky bottoms among kelp.

Maximum total length 18 ins.; weight $8\frac{1}{4}$ lbs.

81. *Leptoscopus macropygus* (Richardson).

Stargazer.

Haast, 1872, p. 275, pl. xvi, fig. 3.

Localities: Inside and outside the harbour, surface to 23 fathoms, never around rocks.

Frequency: No more than one in three months is to be seen. Taken in trawl and seine nets, rarely on the hook.

Size: Maximum total length 20 ins.; weight 3 lbs.

82. *Crapatalus novae-zealandiae* Guenther.

Hutton, 1873, p. 106, pl. xix, fig. 36c.

Localities: Up and down the coast and inside the harbour.

Frequency: Rare; taken about once a month in seine nets.

Size: Maximum total length 21 ins.; weight 1 lb.; average 10 ins.

83. *Parapercis colias* (Forster).

Blue cod. *Rawaru*.

Hutton, 1872, p. 25, pl. vi, fig. 38.

Localities: Up and down the coast from Brinn's Point to Shag Point in from 10–60 fathoms, in the vicinity of rocks and kelp; in the harbour in the summer months.

Frequency: Plentiful; less so than formerly, possibly through overfishing.

Size: Maximum total length 24 ins.; weight 12 lbs.; average 18 ins.; weight 6 lbs.

84. *Katheostoma giganteum* Haast.

Flathead (Chinaman).

Haast, 1873, p. 274, pl. xvi, fig. 2.

Localities: Throughout the harbour, occasionally in Blueskin Bay; present throughout the year.

Size: Usually not more than 12 ins. In March, 1932, a specimen was obtained; length 26 ins.; weight $10\frac{1}{4}$ lbs.; girth 23 ins.

85. *Genyagnus monopterygius* (Bloch and Schn.).

Catfish.

Richardson, 1846, p. 54, pl. xxxiii.

Localities: A specimen was washed ashore after a heavy gale (30/6/30); one caught off Otago Heads in 20 fathoms and two others in the harbour, February, 1933.

Size: Maximum total length 17 ins.; weight $2\frac{1}{4}$ lbs.

86. *Notothenia macrocephala* Guenther.

Maori chief.

Haast, 1873, p. 276, pl. xvi and fig.

Localities: Outside the harbour, especially towards the south; rarely within. Usually among rocks, frequently lying on stones and sand; solitary, in 15-30 fathoms.

Frequency: Present throughout the year; one to six may be taken in one day while fishing for blue cod.

Size: Maximum weight 12 lbs.

87. *Notothenia microlepidota* Hutton.

Black cod.

Waite, 1909, p. 590, fig. 24.

Localities: Occasionally taken among blue cod at Cape Saunders.

Frequency: At times not seen for months and never for more than six.

Size: Maximum total length 21 ins.; weight 5½ lbs.; maximum quoted by Boulenger 16 ins.

88. *Notothenia purpuriceps* Richardson.

Richardson, 1846, p. 7, pl. 2, figs. 3-4.

Localities: Occasionally taken in the channel near the marine station, in 4 fathoms; one from Moeraki, 20 fathoms. Hitherto known only from Kerguelen Island. Specimens distributed to the Otago, Canterbury and Auckland Museums.

89. *Bovichthys variegatus* (Richardson).

Thornfish (horny).

Richardson, 1846, p. 56, pl. xxxiv, figs. 1-4.

Localities: Common at Harrington Point, not otherwise seen in the harbour; common outside, especially at Seal Point; in rock pools and runlets.

Size: Maximum total length 10 ins., average 5 ins.

90. *Gasterochisma melampus* Richardson.

Tunny (sporting tunny).

Waite, 1913, p. 220, pl. viii.

Localities: One specimen caught off Otago Heads (22/5/31). Several others from North Reef; all specimens "foul hooked."

Size: Maximum 200 lbs.; others 30-40 lbs.

91. *Auxis thazard* Lacepede.

Frigate mackerel.

McCulloch, 1934, p. 78, pl. xxxiii, fig. 288a.

One specimen stranded at Otakou Beach, March, 1933; length 32½ ins.; weight 16 lbs. The length is more than twice the figure (15 ins.) mentioned by McCulloch. Not hitherto recorded from New Zealand.

92. *Lepidopus caudatus* (Euphrasen).

Frostfish.

McCulloch, 1934, p. 81, pl. xxxiv, fig. 299a.

Localities: One specimen washed ashore. Occasionally seen in the harbour and at the Kaik.

Size: Harbour specimen 3 ft. 6 ins.

93. *Thyrssites atun* (Euphrasen).Barracouta. *Manga*.

McCulloch, 1934, p. 81, fig. 301a.

Localities: In large or small shoals with or usually without other fish, at times densely occupying many acres at the surface. Large shoals seen 12 miles off shore. Occasionally in the harbour.

Size: Maximum total length 44 ins.; weight 8 lbs.

94. *Jordanidia solandri* (Cuv. and Val.).

Southern kingfish (hake)

Waite, 1911, p. 236, pl. lii.

Localities: Outside the harbour, schooling at or a little above the bottom, 10–20 fathoms in summer, 20–120 fathoms in winter, but occasionally taken in three fathoms; on bottoms of rock, sand or shell. Best localities North Reef, 2½ to 3 miles off Otago Heads, off Tyrone and Cape Saunders, and between Hayward's Point and breakwater at Heads.

Frequency: Abundant at times; the numbers vary greatly from one season to another.

Size: Maximum total length 3 ft.; weight 10 lbs.; average 2 ft.; weight 6 lbs.

95. *Hemerocoetes acanthorhynchus* (Forster).

Opal-fish.

Richardson, 1846, p. 123, pl. liv, figs. 7–12.

Localities: In and without the harbour, 0–120 fathoms.

Frequency: Usually in shoals, occasionally seen singly; common in shallow water.

Size: Maximum total length 9¾ ins.; average 7 ins.

96. *Hemerocoetes waitei* Regan

Waite, p. 245.

Localities: Three specimens examined; two hooked at Port Chalmers, the other from the stomach of a snapper caught in Blueskin Bay.

Size: Maximum total length 11 ins.

97. *Gobiomorphus gobioides* (Cuv. and Val.).

Bulley.

Richardson, 1846, p. 4, pl. xi, figs. 5–6.

Three specimens were caught from a small tidal creek at Portobello.

98. *Eleotris radiata* Quoy and Gaimard.*Kurahina*.

Hutton, 1873, p. 263, pl. 1, fig. 45a.

One specimen, rock pools south of the marine station.

Size: 45 mm.

99. *Acanthoclinus quadridactylus* (Bloch and Schn.)Rockfish. *Taumaka*.

Oliver, 1923, p. 510, pl. xlii, fig. 6.

Localities: Everywhere inside and outside the harbour. Solitary or in small numbers; in rock pools and on broken reefs, often in crevices or under stones; at times on sand or mud, if isolated stones present, e.g., on cockle beds away from shore.

Size: Maximum total length 10½ ins., average 7 ins.

100. *Tripterygion tripenne* (Forster).

Threepenny.

Waite, 1913, p. 3, pl. 1.

Localities: Inside and outside the harbour; usually 0–20 fathoms; evidently reaching deeper level also (found in stomachs of blue cod).

Frequency: Common, but less so than the next species.

Size: Maximum 4 ins., average 3 ins.

101. *Tripterygion varium* (Forster).

Cockabully.

Waite, 1913, p. 7, pl. iii.

Localities: Everywhere, surface to 60 fathoms, on all bottoms.

Frequency: Abundant; the commonest of the local blennies.

Size: Maximum total length 6 ins., average $3\frac{1}{2}$ ins.

102. *Tripterygion segmentatum* McCulloch and Phillipps.

McCulloch and Phillipps, 1923, p. 20, pl. iv, fig. 3.

One specimen, length 56 mm., under stones at Quarry Point, near the station (5/7/30); first record from Otago Harbour.

103. *Helcogramma medium* (Guenther).

Waite, 1913, p. 5, pl. xi.

Localities: Throughout Otago Harbour, especially on clean sand, in rock pools and down to 60 fathoms.

Frequency: Common, but less so than *T. varium*.

104. *Notoclinus fenestratus* (Forster).

Topnot.

Waite, 1913, p. 9, pl. iv.

One specimen off Otago Heads (7/9/33); length 9 ins. Even after some weeks in 4% formalin its bright colours remained unchanged.

105. *Genypterus blacodes* (Bloch and Schn.).

Ling.

McCoy, 1879, pl. xxvii, fig. 1.

Localities: Everywhere within and without Otago Harbour, shallow water to 150 fathoms.

Frequency: Taken throughout the year; they congregate in numbers on good feeding grounds, but can scarcely be called a shoal fish.

Size: Maximum total length 48 ins.; weight 30 lbs.

106. *Helicolenus percoides* (Richardson).

Sea perch, so called John Dory (scroddie, fivefinger, soldierfish, Jock Stuart, Highlander).

Waite, 1921, p. 162, fig. 266.

Localities: One of the most widely distributed fish in Otago waters, occurring everywhere at all depths and inside the harbour.

Frequency: Abundant, numbers constant throughout the year.

107. *Scorpaena cruenta* Richardson.

Red rock cod.

Hutton, 1873, p. 261, pl. viii. fig. 15.

One specimen collected under a rock at Goat Island, Otago Harbour; length $3\frac{1}{2}$ ins. First record from Otago Harbour. Specimens in Otago Museum. Another caught off Taieri Mouth (8/9/32).

108. *Congiopodus leucopocilus* (Richardson).

Pigfish.

Waite, 1921, p. 171, fig. 279.

Localities: Throughout the harbour, outside the bar and Heads, all along the coast 10–20 fathoms; commonest in 0–3 fathoms, less frequent in 50 fathoms, and found in stomachs of groper caught in 100 fathoms.

Frequency: Abundant, sometimes forming shoals.

109. *Neophrnichthys latus* Hutton.

Toadfish.

Arthur, 1884, p. 166, pl. xiv, figs. 5–5a.

Localities: Not uncommon in the harbour and outside to 23 fathoms.

110. *Chelidenichthys kumu* (Lesson and Garnot).

Red gurnard.

Roughley, 1916, p. 184, pl. lxiv.

Localities: Mainly outside the harbour, usually on the bottom to a depth of 23 fathoms, at the surface in shoals of red cod, definitely avoiding rocks.

Frequency: Present throughout the year. Commonest in summer.

Size: Maximum total length 22 ins.; weight 4 lbs.; average 16 ins.

111. *Lepidotrigla brachyoptera* Hutton.

Gurnard.

Hutton, 1872, pl. xv, fig. 41.

One specimen, $5\frac{1}{2}$ ins., was taken while seine netting off Winton's Beach, Otago Harbour (16/2/32); first record for Otago Harbour.

112. *Pterygotrigla picta* (Guenther).

Spotted gurnard.

Waite, 1911, p. 252, pl. lv.

Locality: One $11\frac{1}{2}$ -inch specimen was taken by trawler off Pura-kanui (20/9/33). First record south of the Bay of Plenty.

113. *Diplocrepis puniceus* (Richardson).

Sucker-fish (sucker).

Richardson, 1846, p. 71, pl. xliii, figs. 1–7.

Localities and Frequency: Common under stones and surf-beaten rocks. The fish is, however, not rigorously confined to rocky intertidal stations, for on occasions when weed was abundant on a cockle bank specimens were taken in the seine.

Size: Maximum for females 5 ins., average 3 ins.; maximum for males $2\frac{1}{2}$ ins.

114. *Trachelochismus pinnulatus* (Forster).

Lump-fish.

Guenther, 1861, p. 509.

Localities: Several specimens taken at Harrington Point and Seal Point below low tide mark.

Size: 3 ins.

115. *Trachelochismus littoreus* (Forster).

Cling-fish.

Hutton, 1872, p. 40.

Localities and Frequency: Rare; one taken in the seine net near the station at Tank Bay (unexpected locality and means of capture); one from stomach of red cod, Brinn's Point (11/11/31).

Size: 3½ ins.

116. *Cantherines scaber* (Forster).

Leather-jacket (trigger-fish, file-fish).

Waite, 1911, p. 256, pl. lvi.

Localities: Inside and outside the harbour wherever trawling and seining is carried on; most abundant on the Otago bar; at times in shoals.

Size: Maximum total length 8 ins., average 7 ins.

117. *Sphaerodes richiei* Freminville.

Globe-fish (stink-fish).

Hutton, 1872, p. 72.

Localities: Occasionally trawled outside the Heads.

Frequency: Not plentiful, but formerly abundant.

Size: Maximum total length 5½ ins., average 3½ ins.

118. *Allomycterus jaculiferus* (Cuvier).

Porecupine-fish.

McCulloch, 1921, p. 141, pl. xxxiii, fig. 2.

One specimen, stranded Lower Portobello (30/6/30); first record for Otago.

119. *Mola mola* Linnaeus.

Sun-fish.

Waite, 1913, p. 223, pl. ix.

One specimen examined at Lower Portobello; length 9 ft. 6 ins., width 10 ft. 6 ins. Several others seen in the harbour.

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Food of the Fishes of Otago Harbour and Adjacent Sea.

By DAVID H. GRAHAM, F.R.M.S., F.Z.S.

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SUMMARY.

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INTRODUCTION.

Graham (1938, pp. 399-419).

IN this section the food of fishes is studied in detail, including the types of food, allowing classification of fishes in terms of food to be suggested. From the examination of eleven thousand stomachs of fishes, specific lists are given of the food organisms identified, with an analytical discussion in each case. The list includes fishes, molluscs, crabs, other crustaceans, annelids, echinoderms, plants, and miscellaneous.

SOURCES OF DATA.

Though unavoidably incomplete in many directions, the data collected during the period of study permit an attempt at analysis and deduction, and indeed the importance of this subject, and the central position of the food-problem in the complex of factors which conjointly form the marine environment, demand some such attempts at analysis. The main sources of data concerning diets are as follows:

1. Structural studies, *viz.* examination of the mouth, teeth, gill-rakers, etc. This evidence may be indirect or deceptive, *e.g.*, the discovery that the diet includes microplankton captured by a straining mechanism of gill-rakers does not eliminate the possibility of normal predatory methods by jaws and teeth. On the other hand, this method may detect feeding habits which might not otherwise be indicated, or may explain migratory or other peculiarities.
2. Aquarium observations. These indicate possibilities which should be verified in other ways rather than accepted uncritically as representing normal feeding habits.
3. Examination of stomach contents. This is the most obvious and direct means of investigation, and the one which is most reliable and fertile in its results. There are, however, difficulties, notably those arising from (a) the rapid maceration of food, especially in the case of fast-travelling pelagic species, (b) opportunism, (c) changes in diet with the seasonal changes, growth differences, etc., and (d) the tendency for some fish, especially deep-water fish such as groper, bass groper, and bream, to regurgitate the stomach contents when hooked.

CLASSIFICATION OF FISHES IN TERMS OF FOOD.

The following grouping appears as consistent as any hitherto devised, for although the categories are not mutually exclusive, in that certain species have a claim to inclusion in more than one group, yet this is not due to the choice of heterogeneous bases for the subdivisions, but to the inescapable fact that some species exhibit a much wider range of feeding habits and of foods than most. The basis of classification is in fact strictly homogeneous, in that it concerns exclusively the nature of the food eaten. Unfortunately, circumstances did not permit the preparation of food-lists of the microphages, an especially interesting group in that its members illustrate various stages in the forsaking of macrophagous nutrition (which is ancestral among fishes,

as shown by the dentition), and have abbreviated the usual food cycles by feeding on micro-organisms which normally represent early points in the cycle. To this end there is a tendency for the gill-rakers, originally a straining mechanism for the protection of the gills, to become elaborate sieves whereby micro-organisms are removed from the respiratory current to provide an accessory food supply, or in specialised cases perhaps even the essential food supply. Although the point is too wide to be decided in terms of fishes only, it appears likely that the present provisional classification, strictly in terms of food, may prove less satisfactory than one which takes into account the nature of the food-capturing mechanism. In particular, the group usually referred to as the planktivores is composite in that some members (John Dory, silver dory, boarfish) are microphages with a typical microphagous straining mechanism, others (pilechards, sprat, ahuru, opalfish) feed on small organisms such as copepoda by means of a macrophagous mechanism. Similarly the larval tarakihi is a planktivore, yet perhaps as truly a macrophage as the adult. On the other hand the sand flounder seems to be a microphage in its early stages and later a macrophage. Flounders, though listed as feeding on microbenthos, do so by means of the normal macrophagous mechanism. For these reasons the treatment of the microphages is provisional only.

A. *Macrophages*; feeding on larger (macroscopic) organisms.

I. Indiscriminate devourers of animals and plants ("omnivores")—Red cod, warehou, kahawai, snapper, threepenny, cockabully, leather-jacket.

II. Discriminating between animals and plants, not devouring both.

(a) Carnivorous; feeding on macroscopic animals.

(i) Feeding on the nekton—food-group i, in part food-groups ii, iii, iv: Most sharks; dogfishes; conger eel, hake, bass groper, horse mackerel, yellowtail, barracouta.

(ii) Feeding on macro-benthos—food-groups ii, iii, iv, v, vi, in part I: Skate, elephant fish, silverside, witch, flat-fishes, tarakihi, moki, spotty, girdled parrot-fish, stargazer, *Crapatalus*, flathead, black cod, thornfish, rockfish, red rock cod, toadfish.

(iii) Overlapping composite group; feeding on nekton and benthos: Eel, rock cod, black cod, green-back flounder, bream, groper, trumpeter, blue cod, hake, ling, sea perch, pigfish, red gurnard, sucker.

(b) Phytophagous; feeding on the macrophyton—food-group vii: Garfish, marblefish, kelpfish, scarlet parrot-fish, blue cod, bully.

B. *Microphages*; feeding on micro-organisms and detritus (no food-group prepared).

(i) Indiscriminate devourers of plankton and micro-benthos: Bellows-fish, pipe-fishes, seahorse.

(ii) Discriminating, of limited vertical range.

(a) Feeding on plankton: Pilchard, sprat, minnow, ahuru, roughy, John Dory, silver dory, boarfish, larval tarakihi, *Notothenia*, opalfish.

(b) Feeding on micro-benthos: Moki, flounders (part).

FOOD-GROUP I: FISHES PREYING ON FISHES.

The first table includes the species of fishes found to have been preying upon at least three other species, the predators being named in the vertical column. It so happens that, with the exception of *H. medium*, the prey includes all species of fish known to have been eaten by at least three predators.

TABLE I.—Fishes preying on three or more species of fishes.

PREDATORS.	PREY													Total
	pilchard	sprat	S.S. pipefish	L.S. pipefish	seahorse	garfish	red cod	ahuru	sand flounder	common sole	lemon sole	mullet	warehouse	
tope	X							X	X					3
porbeagle shark	X													3
spined dogfish	X	X						X	X			X		6
skate	X	X			X		X	X	X	X			X	8
conger eel ..														note (a) 3
whiptail ..	X						X	X						3
red cod	X	X	X	X	X	X	X	X	X	X	X		X	note (b) 28
witch	X	X					X	X						4
bream							X						X	4
bass groper ..														note (c) 3
groper	X		X				X	X	X	X	X		X	note (d) 12
kahawai	X	X				X	X			X	X			7
trumpeter ..	X	X	X	X	X									5
blue cod	X	X	X		X		X	X		X	X	X	X	note (e) 16
flathead							X	X	X			X		4
Maori chief ..	X	X					X	X	X				X	9
barracouta ..	X	X					X	X			X	X	X	taumaka 9
kingfish	X						X				X	X	X	5
ling	X	X	X	X	X		X	X	X	X	X	X	X	note (f) 19
sea perch ..	X	X			X							X	X	6
toadfish							X	X	X			X		4
red gurnard ..	X						X	X	X				X	<i>H. medium</i> 7

(a) Conger eel eats marble fish, greenbone, threepenny.

(b) Also smooth-hound, skate, elephant fish, silverside, smelt, witch, rock cod, green-back flounder, greenbone, *H. medium*, leather jacket.

(c) Smooth-hound, javelin fish, whiptail.

(d) Whiptail, bream, yellowtail, and its own young.

(e) Rock cod, bastard red cod, spotty, rockfish.

(f) Lamprey, skate, flathead, triggerfish.

In addition to the above, the following predators were found to have been feeding on only two species:—

Predators.	Prey.	
smooth-hound	sprat	flathead
thresher shark	pilchard	sprat
elephant fish	red cod	lemon sole
hake	pilchard	ahuru
rock cod	cockabully	suckerfish
green-back flounder ..	ahuru	mullet
warehou	pilchard	ahuru
horse mackerel	pilchard	witch
catfish	common sole	<i>Helcogramma medium</i>

Finally, the following cases of predation on only one species were detected:—

Predators.	Prey.
carpet shark	cockabully
sand eel	sea perch
silverside	ahuru
eel	freshwater perch
short-finned eel	freshwater perch
bastard red cod	suckerfish
brill	red cod
sand flounder	ahuru
common sole	pilchard
lemon sole	red cod
yellow tail	pilchard
snapper	pilchard
banded parrotfish	seahorse
stargazer	ahuru
rockfish	cockabully

Analysis of Food-group I.—One important qualification in interpreting these lists is the number of fishes examined. In general, the examination of a very few stomachs of a given species is almost non-significant, whereas a very large number would unduly increase the number of infrequent and unimportant entries. This qualifies the following comment concerning red cod, of which well over a thousand stomachs were examined; the only others in which the number exceeded a hundred were groper (800–1000 stomachs), ling (500–600), blue cod (400–500), barracouta (400–500), smooth-hound (400–450), kingfish (350–450), kahawai (350–400), spined dogfish (350–380), sea perch (300–350), red gurnard (250–350), and bream (200–250). In the other species the number of cases examined was approximately in proportion to the frequency, as elsewhere recorded (Graham, 1938), and as far as possible distributed evenly through the annual cycle.

With these qualifications, points of significance are that:—

- (1) Red cod easily heads the list for the number of species eaten.
- (2) The Elasmobranchs, of no commercial value at present, figure prominently among the predatory fish.
- (3) The flatfish, on the contrary, rely on other sources of food.
- (4) The larger abundant species, including several shoal fishes, make free use of this food supply, as, indeed, from their numbers they are compelled to do. The chief ones are spined dogfish, red cod, groper, kahawai, blue cod, barracouta, ling and red gurnard.
- (5) On the other hand, certain other fishes, some of them even more abundant, smaller in size, depend rather on plankton and other invertebrate sources of food. In this group come the pilchard, sprat, minnow, silverside, smelt, ahuru, three-penny and cockabully.

The last series deserves special attention, because these super-abundant fish, depending on numbers and exuberant fertility rather than size and individual self-protection, are the main sources of food for the fish-eaters. The most important is the pilchard, known from 19 of the 47 fish-eating species; of these, four are ground fish, three others frequent rocky localities, and the rest are rovers. Next in order is the ahuru: it is surprising that such an abundant fish, detected in numbers in red cod stomachs within three days of the commencement of the investigation, had not hitherto been known from Otago waters; it is now known to be eaten by at least 17 species, including six species of ground fish and three of rock fish (whence it is evidently not restricted to the bottom), and must be recognised as a major source of food for fish-eaters, second in importance only to the pilchard. Sprats were found in (if cannibalism can be included in the count) the stomachs of 16 species, and red cod may claim the same distinction; both species inhabit all depths. The cockabully, known from nine species, illustrates the point that the number of species is an imperfect guide to importance in the food cycles, for this fish does not bulk largely in the stomach contents. Other fishes eaten by a number of predators include sea perch (nine species, including cannibalism), mullet, opalfish, seahorse (each seven species), short-snouted pipefish, common sole (six), long-snouted pipefish, sand flounder, lemon sole, pigfish (five), blue cod, barracouta (four). Altogether the lists include 47 predatory species and 48 food-species. More prolonged observations would undoubtedly increase these figures, and meanwhile it would be premature to attempt too close an analysis of the data. *Mustelus antarcticus* (smooth-hound) needs special mention in that though strong, active, swift, and roving by nature, it does not deserve its bad reputation. The vernacular name, and association with shoals of small fish, have led to the belief that it devours fish in large quantities, but an examination of at least 400 stomachs gave evidence of fish-eating on three occasions only; two specimens from Blueskin Bay had 23 and 19 sprats respectively, and one from Quarry Point had eaten two specimens of *Kathetostoma*.

FOOD-GROUP II.—MOLLUSCS.

In table II, showing the fishes found to have been feeding on three or more species of molluscs, and in the supplementary lists, it is to be understood that octopus and squid, which are important foods of many fishes, are each treated as a single species.

TABLE II.—Fishes preying on three or more species of molluscs.

PREDATORS	PREY														Total	
	octopus	squid	<i>Maoricolpura ordinaria</i>	<i>Zethalia zelandica</i>	<i>Zenatia acinaces</i>	<i>Mytiliella vivens</i>	<i>Nucula nitidula</i>	<i>Turbonilla zelandicae</i>	<i>Taurea aptosa</i>	<i>Micrelencchus tenebrosus huttoni</i>	<i>Calliostoma punctulatum</i>	<i>Chlamys celator</i>	<i>Rhyssoplax acraea</i>	<i>Inschnochiton maorianus</i>		Others
smooth-hound	X	X	X	X												4
skate			X	X	X											3
elephant fish			X	X		X	X	X	X						Note (a)	15
red cod	X	X							X	X	X	X			Note (b)	8
brill			X	X			X									3
sand flounder	X	X	X	X	X	X					X				<i>Chione stutchburyi</i> , <i>Gari lineolata</i>	9
g. b. flounder				X				X	X						<i>Amphidesma</i> <i>subtriangulatum</i>	4
common sole			X		X										<i>Paphirus largillierii</i> , <i>Xymene plebeius</i>	4
lemon sole ..			X	X			X									3
warehou			X	X				X	X						Note (c)	8
snapper					X			X							<i>Gari stangeri</i>	3
tarakihi			X						X		X					3
moki								X		X			X		Note (d)	12
trumpeter ..	X	X													<i>Mytilus maorianus</i> , <i>M. canaliculus</i>	4
scarlet p. fish										X		X	X	X	<i>Acanthochiton zelandicus</i>	5
spotty													X		Note (e)	5
girdled p. fish										X			X		Note (f)	7
banded p. fish										X		X		X	Note (g)	6
blue cod	X	X								X	X	X			Note (h)	9
ling	X	X		X												3
pigfish				X											<i>Antisolarium egenum</i> <i>Cantharidella tessellata</i>	3
red gurnard ..	X	X	X	X				X	X						<i>Maoricolpus roseus</i>	7

(a) Also *Antisolarium egenum*, *Notolepton sanguinea*, *Gari stangeri*, *Soletellina nitida*, *Macoma gaimardi*, *Solemya parkinsoni*, *Paphies australis*, *Notosetia* sp., *Zediloma corrosa*.

(b) *Zediloma arida*, *Maoricolpus roseus*.

(c) *Melagraphia aethiops*, *Xymene plebeius*, *Lepsithais lacunosa*, *Cominista glandiformis*.

(d) *Notosetia* sp., *Paphirus largillierii*, *Dardanula limbata*, *Subonoba foveauziana*, *Paricoplax crocina*, *Rhyssoplax canaliculata*, *Amaurochiton glaucus*, *Haliotis iris*, *Atalacmea fragilis*.

(e) *Zediloma arida*, *Dardanula limbata*, *D. olivacea*, also the brachiopod *Terebratula inconspicua*.

(f) *Chlamys zelandicae*, *Chione stutchburyi*, *Amphidesma subtriangulatum*, *Tugali elegans*, *Paricoplax crocina*.

(g) *Haliotis virginea*, *Buccinum mutabile*, *Cellana ornata*.

(h) *Mytilus maorianus*, *M. canaliculus*, *Paradione multistriata*, *Cantharidella tessellata*.

In addition to the seven species in the above table which had fed on cephalopods and other molluscs, the following had fed on both octopus and squid but not on shelled molluscs: seven-gilled shark, porbeagle shark, spined dogfish, conger eel, whiptail bream, groper, bass groper, horse mackerel, yellowtail, Maori chief, barracouta, and (southern) kingfish. The only other species found to have eaten two species of molluscs were seahorse (*Micrelenchus dilatatus*, *Melaraphe cincta*), and greenbone (*Micrelenchus tenebrosus huttoni*, *Melagraphia aethiops*).

Finally, the following are known to have eaten one species only:

Predator.	Prey.	
turbot	<i>Micrelenchus tenebrosus huttoni</i>	
mullet	<i>Tawera spissa</i>	
stargazer	<i>Zethalia zelandica</i>	
catfish	<i>Amphidesma subtriangulatum</i>	
black cod	<i>Mytilus maorianus</i>	
rockfish	<i>Sypharochiton pellisserpentis</i>	
suckerfish	<i>Zediloma corrosa</i>	
silver-warehou ..	squid	

Analysis of Food-group II.—It is not implied that these lists are complete; confirmed mollusc-eaters such as elephant fish and moki undoubtedly consume many molluscs other than those recorded, and the stomachs of these and other species contained quantities of fragmentary material too broken and corroded for satisfactory identification. As it is, 45 species of fishes were found to have eaten molluscs; half of the species had devoured three or more food-species, a third (15) had eaten two species and the rest (8) had eaten one only. The elephant fish heads the list with 15 species. Moki, which comes next with 12 species, appears to swallow much grit and shelled organisms from rocky ledges, including for example remains of chitons, so that the list is incomplete for this species. Sand flounders and blue cod each with 9 species, and red cod with 8 species are closely followed by warehou, red gurnard and girdled parrot-fish.

Reconsideration of the lists in terms of the food-organisms shows that squid and octopus are easily the most frequently mentioned; they are however groups larger than single species. No less than 20 species of fish feed on both, of which 7 feed on shelled molluscs also. The remaining 13 are mostly large roving fishes which prey on other fishes, and for ecological purposes it would clearly be appropriate to group the nektonic cephalopods with fishes instead of with molluscs as sources of food.

Of the shelled molluscs, *Zethalia zelandica* is eaten by 12 species, including benthic and roving species in about equal ratio. Great quantities are commonly eaten by pigfish and others. Similarly, *Maorimactra ordinaria*, the favourite food of elephant fish, is eaten by 10 species, including rovers such as warehou, tarakihi, and red gurnard, which therefore feed at times on the sea floor.

FOOD-GROUP III.—CRABS.

The term "Crab" is here used in an ecological rather than a taxonomic sense, to include not only the Brachyura but also the crab-like Porcellanids of the genera *Petrocheles* and *Petrolisthes*. The distinctness of Filhol's species *Petrolisthes novae-zelandiae* from the common *P. elongatus* was verified, partly from the Portobello collections, by Bennett (1930), but at too late a stage for separate records to be quoted here. The same applies to *Paramithrax*, where most or all of the records refer to the common *P. minor*. The main taxonomic difficulties occurred among the Hymenosomidae, for although several rare species, not recognised since Filhol's description (Filhol, 1885), were secured, such as *Halicarcinus edwardsi* from red cod, the boundaries of the commoner species are at present too ill-defined to allow close specific distinctions; hence "*Halicarcinus* spp." is a group-name for species with tridentate rostra, and "*Hymenicus* spp." for those with trilobulate lamellar rostra. The name *Hombrowia* is revived for a swimming crab hitherto regarded as rare, but now recognised to be not only generically separable from other members of the family, but ecologically of major importance.

TABLE III.—Fishes feeding on three or more species or groups of crabs.

PREDATORS	PREY											Others	Total
	<i>Paramithrax</i> sp.	<i>Halicarcinus</i> spp.	<i>Hymenicus</i> spp.	<i>Hombrowia depressa</i>	<i>Cancer novae-zelandiae</i>	<i>Nectocarcinus antarcticus</i>	<i>Onmatocarcinus macgillivrayi</i>	<i>Hemigrapsus aculeatus</i>	<i>Hemigrapsus orenulatus</i>	<i>Cyclograpsus lavaeum</i>	<i>Heloe crassa</i>		
smooth-hound	X	X	X	X	X	X	X	X	X	X	X		10
spined dogfish				X	X	X				X			4
skate	X	X	X	X	X								4
red cod	X	X	X	X	X	X	X	X	X	X	X		
												<i>Hemiplan hirtipes</i> , <i>Petrocheles spinosus</i>	13
rock cod	X	X	X	X	X			X		X			6
bastard red cod	X	X		X									3
brill	X	X		X	X								3
sand flounder	X	X		X	X						X		5
green-b. flounder ..	X	X	X	X	X								4
lemon sole	X	X		X	X								4
tarakahi	X		X		X					X			4
moki	X	X	X	X	X					X			5
spotty	X	X	X	X	X						X		5
stargazer					X	X	X						3
blue cod	X			X	X							<i>Petrocheles spinosus</i>	4
Maori chief	X			X	X							<i>Eurynotambrus australis</i>	4
barracouta	X			X	X								3
ling	X		X	X	X	X							5
sea perch	X	X	X	X	X		X	X	X	X		<i>Leptomithrax longipes</i>	10
pigfish	X	X		X	X								3
toadfish				X	X	X							3
red gurnard	X	X	X	X	X	X		X	X	X		<i>Hemiplan hirtipes</i>	9

The following were found preying on two species or groups:—

Predators.	Prey.	
mullet	<i>Nectocarcinus antarcticus</i>	<i>Halicarcinus</i> sp.
gurnard	" "	" "
<i>Crapatalus</i>	" "	<i>Hombronia depressa</i>
breem	" "	<i>Paramithrax</i> sp.
black cod	" "	" "
hake	" "	<i>Cancer novae-zelandiae</i>
witch	" "	" "
warehou	" "	" "
groper	" "	" "
carpet shark	<i>Hemigrapsus crenulatus</i>	" "
flathead	" "	" "
elephant fish	<i>Halicarcinus</i> sp.	<i>Hombronia depressa</i>
thorn fish	" "	<i>Petrocheiles spinosus</i>
common sole	<i>Hymenicus</i> sp.	<i>Hombronia depressa</i>
suckerfish	<i>Hemigrapsus crenulatus</i>	<i>Petrolisthes</i> sp.

Finally, the following were found to prey on only one species or group:—

On *Nectocarcinus antarcticus*: conger eel, horse mackerel, kaha-wai, snapper, trumpeter, scarlet parrot-fish, banded parrot-fish, kingfish.

On *Petrolisthes* sp.: rockfish, threepenny, cockabully, red rock cod.

On *Cyclograpsus lavauzi*: silverside.

On *Hombronia depressa*: turbot.

On *Hemigrapsus sexdentatus*: girdled parrot-fish.

Analysis of Food-group III.—It follows that 52 species of fishes were found to have been feeding on a total of 16 species and higher groups of crabs. The chief predator is red cod, with 14 species, followed by smooth-hound and sea perch, each with 10, and red gurnard with 9. No doubt further investigations would increase the number of predators and of prey, but the list suffices to show that a considerable number of important fish depend largely on crabs for their food. Lists compiled in this way are defective in not being quantitative, but it may be said that in general fishes which eat crabs do so frequently and in great numbers; stomachs of red cod, for example, are often found crammed with crabs, suggesting that other food is neglected if crabs are available. The importance of the planktonic zoeal stages can only be presumed, and a further item must be credited to the crabs in that a number of the predators in the present list appear as prey in food-group I; that is, fishes which eat few or no crabs may feed on fishes which depend largely on crabs.

The crab most abundantly consumed was *Nectocarcinus antarcticus*, a prolific swimming species which frequents all depths and was seen in abundance after dark at the surface. If acclimatisation of supplementary food supplies for marine fishes is mooted in other areas of similar latitude, this species is undoubtedly New Zealand's first suggestion. It is known from 37 species, including bottom fish and rovers, and is commonly consumed in great quantities.

Next on the list comes another swimming species, *Hombromia depressa*, known from 22 species of fishes. Other Hymenosomids prove to be of greater importance than hitherto suspected, making up in numbers what they lack in size. *Cancer novae-zelandiae* is a benthic crab known from 19 species, and the severe toll taken by fishes suggests a reason for the failure to establish a European congener in New Zealand waters after several years' trial at the station.

Petrolisthes was found in 9 species of fishes, but not frequently and not in large numbers, so that their importance is less than might be inferred from the number of entries. Both species are seclusive, hiding under stones and clinging tightly when disturbed; and their relative infrequency in fish stomachs, in spite of their extreme abundance on shallow bottoms, confirms the inference that these cryptozoic habits, in conjunction with their flattened shape and inconspicuous bluish-grey colours, are of protective value in an environment which proves precarious for less effectively concealed species. A case in point is that of *Hemigrapsus crenulatus*, a very abundant species in estuaries and on reefs, more venturesome in habits, and although active and armed with massive chelae, not provided with any noteworthy means of concealment; it is eaten in great quantities, notably by red cod from the harbour, and ranks very high as a source of food for fishes. The fact that it is known from only 8 species of fishes emphasises the contrast with *Petrolisthes*, and shows how a list of entries could be fallaciously interpreted if not qualified by quantitative data. The suggestion that *Hemigrapsus crenulatus* defends itself by its activity and strength and by its strong chelae is somewhat strengthened by the relative immunity of its congener *P. sexdentatus* from attack, save by a few of the larger fishes. This crab is known only from four species, and is characterised by its large size, unusually formidable chelae, and bright red colour; possibly the conspicuous pigmentation, in contrast to that of its drab mud-coloured relative, serves as a warning device.

It would appear that swimming habits (*Hombromia*, *Nectocarcinus*) imply a heavy toll and a dependence for racial survival on prolific breeding, as in other relatively small organisms of the nekton (sprat, pilchard, whalefeed) and of the plankton (Copepods); that relatively defenceless benthic crabs (*Halimacarcinus*, *Hymenocarcinus*, *Cancer*) also require in a lesser degree a high fertility in order that the species may survive; that cryptozoism and concealment colours (*Petrolisthes*) may have genuine protective value; that bulk and massive weapons (*Leptomithrax*, *Jacquemithrax*) may give partial or even complete immunity from attack; that these defences may be effectively supplemented by warning colours (*Hemigrapsus sexdentatus*); and that there is a refuge from many species of predators in estuaries (*Helice crassa*, *Hemiplax hirtipes*) and at similarly higher levels on the beaches (*Cyclograpsus lavauxi*). Without closer discrimination of species it is difficult to determine the functional value of the supposedly protective mask of weeds (*Paramithrax minor*, *P. longipes*) or hairs (*P. ursus*) or sessile animals (*Leptomithrax* spp.) characteristic of the Majoid crabs.

FOOD-GROUP IV.—OTHER CRUSTACEA.

The more conspicuous Crustacea were recorded under specific or group names as in Table IV, which includes fishes found to be feeding on at least three non-brachyurous groups as defined.

TABLE IV.—Fishes feeding on at least three species or groups of crustaceans.

PREDATORS	PREY											Total	
	<i>Squilla armata</i>	Whalefeed (<i>Munida gregaria</i>)	Crayfish (<i>Jasus lalandii</i>)	<i>Pontopitius australis</i>	<i>Alope palpalis</i>	<i>Brachycarpus audouini</i>	<i>Nyctiphanes australis</i>	Amphipods	Other Isopods	Calanids	Other Copepods		Others
smooth-hound ..	X	X	X	X	X				X			<i>Eosphaeroma gigas</i>	7
spined dogfish ..	X		X			X		X	X				5
red cod	X	X	X	X		X	X	X	X		X	<i>Idotea elongata</i>	10
warehou		X				X				X		Ostracods	4
snapper		X				X	X					Ostracods	4
tarakihi		X						X	X				3
moki		X				X			X			<i>Hippolyte bifidirostris</i>	4
blue cod	X	X	X		X	X						Note (a)	8
barracouta .. .	X	X			X	X						<i>Euthemisto thomsoni</i>	5
cockabully .. .								X	X		X		3
ling		X	X	X		X	X						5
sea perch	X	X										<i>Palaemon affinis</i>	3
red gurnard .. .	X	X				X							3
silverside .. .		X							X			<i>Erosphaeroma gigas</i>	3
seahorse								X	X				2
sand flounder ..	X							X	X				3

(a) Also *Hippolyte bifidirostris*, *Idotea unguolata*, *Phronima novae-zelandiae*.

The following species fed on two of these groups (specific names as in preceding table) :—

Predators.	Prey.
elephant fish	whalefeed <i>Brachycarpus</i>
sand eel	Amphipods Isopods
rock cod	<i>Squilla</i> <i>Idotea elongata</i>
common sole	whalefeed <i>Brachycarpus</i>
groper	whalefeed crayfish
kahawai	whalefeed <i>Nyctiphanes</i>
greenbone	whalefeed Caprellids
banded parrot-fish ..	Pagurids Cirripedes
rockfish	Amphipods Isopods
<i>Heleogramma medium</i> ..	Caprellids Copepods
pigfish	Caprellids other Isopods

Twenty-five species of fish were found to have fed on one only species or group of crustaceans, as follows:—

On whalefeed: carpet shark, skate, hake, witch, lemon sole, half-banded sea perch, trumpeter, spotty, girdled parrot-fish, southern kingfish.

On *Brachycarpus audouini*: blind numbfish, turbot, green-back flounder, *Hemerocoetes waitei*.

On Copepoda: minnow, ahuru, boarfish. *Notothenia purpuriceps*.

On *Paranephrops*: eel, short-finned eel.

On Caprellids: bellows fish.

On Calanoids: pilchard.

On *Nyctiphanes australis*: silver dory.

On *Alope palpalis*: thornfish.

On Isopods: lump fish.

Analysis of Food-group IV.—Red cod head the list with 10 groups or species, but as already noticed, more stomachs of this fish were examined than of any other. Other fishes prominent in this series are blue cod (8 groups or species), smooth-hound (7), spined dogfish, barracouta, ling (5). But by far the most important conclusion is the extremely valuable role of whalefeed, of which the bottom and swimming forms, in their extraordinary though seasonal abundance, provided enormous quantities of food for at least 26 species, including 10 species not known to feed on any other non-brachyurous crustacea.

Brachycarpus audouini, eaten by 13 species, and *Nyctiphanes australis*, eaten by only nine, but taken in great quantities, are also of major importance as food for fishes. Closer study would no doubt add to the list of those feeding on Copepoda and other minute forms. The above records do not attempt to evaluate the part played by the larval and other planktonic forms.

The abundance of whalefeed eaten by red cod must have a considerable bearing on the food value of this much-despised fish; the body-fat of red cod has been found (Carter and Malcolm, 1926, p. 648) to show a close seasonal agreement with the available supplies of whalefeed. In the swimming stages whalefeed was found to feed principally on diatoms.

FOOD-GROUP V.—ANNELIDA.

As in the case of other wholly soft animals, the rapid maceration implies an incompleteness of records; but there is already ample evidence that worms are by no means a negligible fraction of the diet of some important fishes.

TABLE V.—Species of fishes feeding on at least three species of worms.

PREDATORS	PREY									Total
	<i>Glycera ovigera</i>	<i>Physalidonotus squamosus</i>	<i>Nereis australis</i>	<i>Nereis amblyodonta</i>	<i>Nereis vullata</i>	<i>Timarete anchylochaetus</i>	<i>Eunice australis</i>	<i>Lepidonotus polychroma</i>	<i>Eulalia microphylla</i>	
smooth-hound..	X			X						6
spined dogfish	X	X	X		X	X				5
red cod	X	X	X			X	X			5
sand flounder ..	X		X	X		X	X	X		8
									<i>Lumbriconereis sphaerocephala</i> , <i>Aphrodite talpa</i>	
common sole ..	X					X		X	<i>Gonida grahami</i>	4
moki	X						X	X		3
blue cod	X	X	X				X	X		5
sea perch .. .	X	X	X							3
red gurnard ..	X		X		X			X		4

(a) Also *Lumbriconereis sphaerocephala*, *Aphrodite talpa*, *Phycosoma annulata*, *Hemipodus simplex*.

The following cases of predation on two species were noticed:—

Predators.	Prey.	
skate	<i>Glycera ovigera</i>	<i>Physalidonotus squamosus</i>
witch	" "	" "
brill	" "	" "
warehou ..	" "	" "
tarakihi ..	" "	<i>Timarete anchylochaetus</i>
greenbone ..	" "	<i>Lepidonotus polychroma</i>
spotty	<i>Nereis amblyodonta</i>	<i>Eulalia microphylla</i>
pigfish .. .	<i>Harmothoe praeclaræ</i>	" "
lemon sole ..	<i>Lepidonotus polychroma</i>	" "

Single species were identified in the following cases:—

Glycera ovigera: silverside, rock cod, stargazer, barracouta.

Terebellids: yellow-belly, black flounder.

Nereis amblyodonta: mullet.

Eulalia microphylla: girdled parrot-fish, thornfish, suckerfish.

Timarete anchylochaetus: rockfish.

Finally, Nemertines were recovered from the green-back flounder.

Analysis of Food-group V.—In addition to the Terebellids and Nemertines 15 species of worms were recognised among the stomach contents. Much the most frequent was *Glycera ovigera*; save for *Physalidonotus squamosus* and *Eulalia microphylla*, the rest occurred in only one or a few species. It would however give a false impression of the role of Annelids as sources of food if these results were treated as approaching completeness.

The fishes most dependant on worms are the smooth-hound and the sand-flounder, from each of which seven species were recognised, in addition to Terebellids in the latter fish. In general, the benthic fishes, notably the smaller Elasmobranchs and the flat fishes, are the chief users of this source of food.

FOOD-GROUP VI.—ECHINODERMS.

Echinoderms were eaten as follows:—

TABLE VI.—Species of fish feeding on echinoderms.

PREDATORS	PREY			
	Chiradota	Cucumaria	<i>Evechinus chloroticus</i>	Ophiuroids
smooth-hound ..		X		
elephant fish			X	
sand eel				X
red cod		X		
witch	X			X
sand flounder				X
black flounder				X
common sole	X			X
lemon sole				X
ling				X

Analysis of Food-group VI.—Although the echinoderm fauna is limited in species, the entries are few and the absence of asteroids especially noteworthy—the more so as they could scarcely be overlooked if present. The main conclusion is that several flatfishes and a few other bottom-feeding species ingest ophiuroids and occasionally other echinoderms. The role of echinoderm larvae in the food cycle of the plankton remains uninvestigated.

FOOD-GROUP VII.—PLANTS.

TABLE VII.

PREDATORS	PREY			
	<i>Zostera marina</i>	<i>Ulva lactuca</i>	<i>Macrocyctis pyrifera</i>	Algae various
garfish	X	X		X
sand flounder	X	X		
mullet		X		X
marblefish		X	X	
trumpeter		X	X	
scarlet parrotfish ..		X	X	
greenbone		X		
blue cod		X	X	

Analysis of Food-group VII.—Obviously no serious attempt has been made to distinguish the species of algae, and the phytoplankton remains uninvestigated. In some cases there are grounds for doubting whether the weeds are eaten for their own food-values or for that of the molluscs and crustaceans swallowed with them. Phytophagous fish are likely to have a high iodine content.

FOOD-GROUP VIII.—MISCELLANEOUS.

Analysis of Food-group VIII.—Scyphozoans were recovered from elephant fish, actinozoans from blue and black cod, and hydrozoans from moki, red cod and marble fish. These coelenterates are of minimal nutritional value, and little more could be claimed on behalf of polyzoans (marble fish), salps (elephant fish, warehou, trevally) or simple ascidians (red cod) or compound ascidians (bream, trigger fish). Flotsam in the form of petrels was found in the stomachs of groper, ling, and red cod, and to the scavenging habits of the last were further demonstrated by the discovery of various mammals.

SUMMARY.

The smooth-hound is exonerated from the current lay accusation of scavenging propensities.

From the above tables it will be seen that, with few exceptions, the food of larval fishes has been omitted; this is due to the almost impossible task of identifying the microscopic forms found therein. Only macro-organisms have been identified, analysed, and included in the foregoing classification, but this has been regarded as a necessary preliminary to the fuller investigation which should eventually include a study of the micro-organic food supply as well.

ACKNOWLEDGMENTS.

From the nature and scope of the work, it is clear that such a paper would not have been possible were it not for valuable help from many sources. Specialists who have named material belonging to various groups include Dr. W. B. Benham (Annelida), Dr. E. W. Bennett (Echinoderma, Brachyura), Dr. H. J. Finlay (Mollusca), Dr. C. E. Laws (Mollusca), Mr. A. W. B. Powell (Mollusca), and Mr. R. M. Laing (Algae). For the correct usage of the data supplied the author must accept full responsibility. Finally, I wish to thank Dr. E. W. Bennett for helpful assistance in the preparation of this paper.

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The Development of the Antheridium, Archegonium, and Sporogonium of *Cyathophorum bulbosum* (Hedw.) C. M.

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INTRODUCTION.

Cyathophorum is a small genus of Mosses placed in the Hypoterygiaceae and found in Eastern Australia, Tasmania and New Zealand. As regards the total number of species, and how many occur in the latter country there appears to be some confusion.

W. Wilson (34) in Hooker's *Flora Novae Zelandiae*, 1855, listed one species *Cyathophorum pennatum* Lab. and two varieties *minus* and *apiculatum*.

V. F. Brotherus (10), 1924, gave two species *C. densirete* (Broth.) and *C. bulbosum* (Hedw.) C. M. (Syn. *C. pennatum* Bridel. *Bryol. Univ.*, 1927), both of which he stated occur in New Zealand.

In 1913, however, H. N. Dixon (15) had adopted the original view of Hooker and Wilson and had reduced *C. densirete* (Brotherus) in *Oefv. af. Finska. Vet-Soc. Foerh.* XXXV 40—previous to 1913) to the status of a variety. He listed but one New Zealand species *C. bulbosum* and a variety *minus*—"the limits of which moreover are difficult to define" (Dixon, *loc. cit.*). New Zealand botanists are inclined to follow H. N. Dixon's nomenclature.

The present paper deals with the development of the sex organs and sporogonium of *Cyathophorum bulbosum* (Hedw.) C. M. together with a short ecological account of the species. An account is also given of the methods of killing and fixing, infiltration, etc., used by the writer, as these processes offer some difficulty.

This paper forms part of a thesis submitted for the degree of Master of Science in the University of New Zealand. The work was carried out at the Department of Botany, University of Otago, under the direction of Dr. J. E. Holloway, F.R.S., to whom the writer would like to express his sincere thanks for helpful criticism and advice.

Material and Methods.

Material was collected from numerous localities in both North and South Islands, over a continuous period of fourteen months. Over fifty collections were made in the vicinity of Dunedin. Some killing and fixing was done in the field, but the majority of plants were brought to the laboratory and kept in damp Wardian cases, when the necessary microscopical dissection could be more conveniently carried out.

Killing and Fixing.

As a group, mosses appear to offer considerable difficulties in fixing [Chamberlain (1); Wilson (33); Bryan (12).] Air bubbles are troublesome, cell walls especially in the older capsules are thick, and also at certain points in the life history (notably in very young embryos and older antheridia) it is commonly found difficult to get good results. Several fixing reagents were employed by the writer and although generally good results were eventually obtained, it was only after considerable experiment.

An air pump was used on every occasion with the exception of material killed in the field. Capsules were as a rule pricked gently in several places with a sharp needle, to aid both in penetration of the killing and fixing agent and to ensure good infiltration of paraffin at a later stage.

The following fixing agents were employed:—

I. Chrom-acetic acid mixtures. [Chamberlain (1).]

(a) "Strong," (b) "Stock," (c) "Weak."

II. Chrom-acetic acid-formalin (Licent's formula).

III. Formalin acetic alcohol.

(a) 5 ccs. glacial acetic acid; 5 ccs. com. formalin; 90 ccs. of 70% alcohol. (b) 5 ccs. gl. acetic acid; 10 ccs. com. formalin; 85 ccs. of 70% alcohol. Other combinations using 50% alcohol were tried, but the results were the same as with the above two formulas.

IV. Absolute alcohol.

V. Carnoy's fluid (using 95% alcohol).

The variety of objects in which study was attempted, namely, embryos and older sporogonial stages, antheridia and archegonia, made it certain that no one killing and fixing agent was likely to be equally successful with all types. Wherever possible, therefore, material was killed in at least two different reagents and the results compared. In the following account the various objects are taken separately and the results with different killing and fixing agents discussed in some detail.

Embryos or Young Sporogonia: For very young embryos none of the above reagents were very successful. Chrom-acetic acid mixtures were useless, causing the tissues to shrink and even break up. This was more apparent in the foot region of the embryo than elsewhere. Various times were tried from 6–48 hours, but the results were all poor—the longer periods being worse than the short. Formalin-acetic-alcohol [formula (a)] gave good results with all embryos after the apical cell had cut off a few segments, but for earlier stages it was only fair. However, it was distinctly better than any other agent tried. The time for fixing is fairly short (6–12 hours), but some material collected in the North Island remained in this fluid for some three months and still gave excellent results. Carnoy's fluid was not tried for very young embryos, as only a limited number were obtained. For older stages, however, it was good, and almost equal to the formalin acetic alcohol. The time that material was left in the reagent affected it greatly. Embryos left for up to 18 hours gave good results, but after this collapsing began, and one lot left for two days was quite spoiled.

Older Sporogonia: Young capsules with sporogenous tissue just set apart gave good results after fixation in formalin acetic alcohol [either formula a or b]. In the later stages, however, the alcohol may have tended to harden the material a little, and capsules of this stage cut more successfully after fixing with "strong" chrom-acetic acid for 48 hours. Carnoy's fluid was good for the young stages of development of the sporogenous tissue and, of course, penetrated excellently. For the later stages, however, it was poor. Capsules dropped into the fluid about the "spore tetrad" stage usually burst near the apophysis and the contents was extruded in a long spiral.

Archegonia: Strong chrom-acetic acid and Licent's formula gave good results, although in a few cases a little plasmolysis occurred. Chamberlain (*loc. cit.*) recommends long periods for fixing in the chrom-acetic mixtures. This was accordingly followed, the usual time being 36–48 hours. Equally good results were obtained, however, by fixing for only 18 hours. Washing was done in running tap water. Carnoy's fluid was found to cause more or less plasmolysis if allowed to act for more than 18 hours, but with shorter times was quite good.

Antheridia: Young stages, up to the cutting off of the central spermatogenous tissue offer far less difficulty than do the later stages. In the latter shrinkage frequently occurs, due no doubt to the mucilaginous nature of the contents with poorly defined cell walls. Chrom-acetic acid ("strong" and "weak" above) and Carnoy's fluid caused plasmolysis in all but the young antheridia. Absolute alcohol caused no shrinkage even in the later stages, but formalin acetic alcohol again proved to be the best of the reagents tried. It caused no plasmolysis at any stage and staining with haematoxylin was brilliant. The time for fixing seems immaterial and objects may be left in the solution for months.

Dehydration and Infiltration.

Following Chamberlain (1) a very gradual series was used in the passage from alcohol to xylol and paraffin. While this appears necessary for detailed cytological work a less gradual series gave equally good results in the present research.

Owing to the hard wiry nature of the main stem, sectioning of antheridia or archegonia is practically impossible unless the "tufts" (Fig. 2) are dissected off and handled separately. Although this is extremely tedious, it is by far the most successful method, and for median sectioning of young sporogonia the only one, owing to the manner in which they curve away from the stem.

It was found difficult to get complete sections of older capsules due to the fact that the peristome teeth tore away from the other tissues. In an attempt to overcome this, two methods were tried:

(1) A long period of infiltration followed by some weeks on the paraffin bath, in paraffin (51° C.).

(2) The use of hydrofluoric acid (Langdon 5). This was tried with 10% acid for periods varying from two to five days. Later both the above methods were combined, as material treated with hydrofluoric acid was also given a prolonged time on the bath for infiltration. Capsules treated in this latter manner gave much improved results although for the mature peristome even this was only partially successful.

Staining.

The following stains were employed: Haidenhain's Iron Alum Haematoxylin; Delafield's Haematoxylin; Safranin and Light Green (in clove oil); Gentian Violet; Orange G and Erythrosin were both used with the haematoxylin as counter stains. For the older capsules Safranin and Light Green was good—the walls of the spores and teeth of the peristome staining a bright red. Delafield's Haematoxylin and Orange G gave excellent results with antheridia. For embryos Haidenhain's Iron Alum Haematoxylin was very good, staining both the cell walls and the nuclei—the addition of Orange G gave much better differentiation.

When using the Iron Alum Haematoxylin destaining was tried with 4% Ferric Ammonium Sulphate or with a saturated solution of Picric Acid (Tuan H'su Chuan. 6). The latter was much more successful, especially when the sections were washed for five minutes afterwards in Scott's Tap Water Substitute.

Sections were cut on a Cambridge rocking microtome or on a heavy sledge microtome and varied from 5–18 microns in thickness, depending on the object to be sectioned. Drawings were done with an Abbé camera lucida or a Leitz projection drawing apparatus.

GENERAL ACCOUNT OF *Cyathophorum*.

(a) *Ecology.* *Cyathophorum* occurs in mixed wet forest and is absent from or much rarer in the drier *Nothofagus* forest. It appears to be a generally epipetrous species (Verdoon 32), although in a sufficiently humid atmosphere it is often found on exposed roots,

fallen tree trunks, etc. It is in general not very plentiful. As a rule *Cyathophorum* forms pure colonies often covering a few square feet—the largest observed by the writer was some six feet by three feet. Frequently it is found in clumps of a few score plants on boulders or rocks in creek beds, etc.

The factor limiting its distribution would appear to be the humidity and the generally damp condition of the substratum rather than light intensity. The species has been found in a great variety of situations, ranging from places where light intensity was very low to those where the plants grew in bright light—always, however, the station was decidedly damp.

The plants may actually grow with water falling on them, but this is unusual and only one such habitat was observed. All the plants here were sterile.

(b) *Gametophyte*. The mature gametophyte develops from a protonemal stage as is usual in Mosses. The spores are green when shed, with large obvious chloroplasts, oil droplets and practically no exospore.

To obtain mature spores, capsules were artificially ripened by drying slowly in a Wardian case. For culturing protonemata broken bricks were used. These were sterilised with 4% formalin, boiled in water for half an hour and then stood in glass dishes with distilled water. The spores were sown at room temperature (viz. about 15° C.) and the cultures kept under bell jars. They were left alone for some weeks and as growth appeared slow, drops of Knopp's Solution were pipetted on, and allowed to run down the slope of the brick. This caused more vigorous growth and buds soon developed on the protonemata.

Spores were found to have germinated a day after sowing and development was quite normal. The spore swells slightly and a blunt protuberance is pushed out through the exospore which splits. With further growth and transverse divisions an "alga-like" filament of indefinite length is produced with plentiful oval chloroplasts—a distinguishing feature from the green algae that frequently occur with the plants in nature. The erect gametophores arise on the protonema in the usual way.

The mature gametophore of *Cyathophorum* consists of a stem from two to ten inches in length bearing leaves arranged dorsiventrally (Fig. 1). There are two rows of large dorsal leaves extending laterally, and a single row of small ventral leaves. Usually the stem is unbranched, but a number of instances were seen where branching had occurred. This is an abnormal feature and will be referred to later.

The base of the stem ends in a thickish rhizomatous axis which can creep to some extent and turn erect. This is apparently a method of vegetative reproduction, as the apex, when it does turn erect, gives rise to a new leafy axis.

(c) *Sex Organs*. *Cyathophorum* is strictly dioecious. The sex organs are borne terminally on small branches in the axils of the dorsal leaves (Fig. 2) and are overlapped by the leaves of the ventral

row. Both antheridial and archegonial branches have an investment of small leaves enclosing the sex organs and paraphyses. The latter are much more abundant in the antheridial tufts, where they have somewhat swollen heads. Paraphyses do occur among the archegonia, but there are very few and they are much smaller than those in the male tufts.

Archegonial plants seem to be much more plentiful than the antheridial, and frequently whole colonies—in some cases feet across—were found composed entirely of the former.

A similar example is quoted by Johnson (23) for *Plagiochila adiantoides*. He advances the explanation that vegetative propagation from a few original pioneers, all female, is responsible for these large collections of one-sexed colonies.

Antheridial plants are found in similar patches, but here they are usually limited to a few dozen plants.

In most of the localities listed above *Cyathophorum* is plentiful. Yet in spite of this fact the percentage of plants found to be bearing sporogonia is surprisingly small—probably not more than about 10%.

The explanation seems to be due primarily to the separation of the sexes as mentioned above. There is no lack of either male or female plants, but the occasions on which they are intermixed in such a way to allow fertilisation to take place seem to be by no means frequent. This conclusion is borne out by the fact that when plants of different sexes are found together practically every archegonial plant bears several sporogonia.

The following instance may be given in illustration of this:—Sporogonia at several stages of development were found on all of a small clump of plants (about 10–20), growing on a vertical rock bank by a waterfall. No male plants were present among these, and they appeared quite isolated. However, two or three feet above this were found a number of antheridial plants with water dripping from them on to the female plants below. Clearly fertilisation had been most efficient. In contrast with this, hundreds of archegonial plants on a bank alongside had not a single sporogonium.

A longitudinal section of a sex branch shows a definite central zone of elongated cells which run into the cortex of the stem but do not attach themselves to the main strand in the latter. As already noted, a much-branched main axis is occasionally met with. This condition seems to arise from the antheridial or archegonial branches failing to form sex organs and the apical cell of some of these branches growing on to give leafy branches of some length. In all cases examined these laterally branched plants were completely sterile. Other cases were observed where instead of sex organs there was a large tuft of secondary protonemata. These tufts usually occurred in the axils of half a dozen or so of the leaves nearest the apex of the stem.

Considerable attention was given to ascertaining the season when the sex organs mature, and it can be stated that for New Zealand as a whole, sex organs and sporogonia can be found in any

stage of development in any season of the year. However, in any one locality this will not be the case, and the sex organs will show a periodicity in development. With any one plant it would be expected that but one crop of antheridia or archegonia would be borne per season and this is borne out by the fact that large plants are sometimes found with a crop of old (last season's?) sex organs towards the base and young or mature ones nearer the top. How far this periodic development holds in the different patches of *Cyathophorum* along one creek, for example, cannot be said, as more detailed observation over some years would be necessary to establish such a point with any certainty.

(d) *Sporogonium*. The sporogonia occur on the underside of the stem and hang downwards, the number on any one plant varying from one to about fourteen. There seldom appears more than one mature capsule from any one archegonial clump. Two or more archegonia in a clump may be fertilised and embryos develop up to a certain stage, but eventually one outstrips the others, which abort, the successful embryo going on to produce the mature sporophyte.

The vaginula is obvious and remains on the gametophore after the capsule has withered and fallen.

Microchemical tests show that in the cells at the apex of the sex branches there is a great concentration of large oil droplets, which stain deeply with Sudan III. These oil droplets also occur in the actual wall cells of the archegonial necks. When the embryo develops, oil is still abundant in the gametophytic tissues, but is absent in the embryo itself. A number of cases were found where the venter had swollen and undergone secondary growth but where there was no embryo present. This apparently was a case of secondary growth in an archegonium that had been unfertilised—in all these cases oil was abundant not only in the cells of the venter but also in those of the calyptra.

DEVELOPMENT OF THE ANTHERIDIUM.

The developmental series described below is based upon serial sections of over fifty antheridial tufts.

The antheridia develop from surface cells at the apex of the antheridial branch. Whether or not the apical cell of the branch itself gives rise to the first antheridium as in *Fontinalis* and *Andreaea* (Sachs 30, p. 372) cannot be said, as it was not found possible to trace any regularity in the order of formation of the antheridia. A surface cell protrudes very slightly and an oblique wall is formed in it, cutting off an apical cell with two cutting faces (Figs. 5–6). *Cyathophorum* in this respect evidently differs from *Funaria hygrometrica* (Campbell 13), *Fontinalis* and *Sphagnum* (Sachs 30). For *Funaria*, Campbell states “a superficial cell projects above its neighbours and this papilla is cut off by a transverse wall. The outer cell either becomes at once the mother cell of the antheridium, or other transverse walls may occur so that a short pedicel is first formed.”

In *Cyathophorum* nothing in the nature of a pedicel was observed before the advent of the apical cell. This functions immediately after the first oblique wall is formed (Figs. 5–6) cutting

off two rows of segments in the usual regular succession (Figs. 7-9). Obviously, owing to the absence of any pedicel, the stalk of the antheridium in the early stages of development cannot be distinguished definitely. All that can be said is that the lower segments (i.e., the first cut off by the apical cell) constitute the basal part of the stalk, while its upper limits are indefinite until periclinal walls appear in those segments destined to give rise to the body of the antheridium (Figs. 11-12).

Before these appear there is often a certain amount of subdivision of the lower segments cut off by the apical cell although the extent to which this occurs is variable and in general affects the lower portion of the stalk rather than the upper.

The number of segments cut off by the apical cell varies, but is usually about eight. Before the full number is attained secondary divisions begin in the lowest of the segments and extend upwards.

As seen in longitudinal section (Figs. 10-11) these divisions appear as periclinal walls cutting off an inner series of cells, the forerunner of the spermatogenous tissue, from a peripheral series which constitutes the antheridial wall.

How this is accomplished can only be made out clearly by a comparison of longitudinal with transverse sections of the antheridium. Before periclinal division sets in, a transverse section through a young antheridium shows two segments separated by their bounding wall. (Fig. 12.) The divisions which follow are best described with the aid of a diagram (I).

The original wall separating adjacent segments is represented a-a. The advent of periclinal division is marked in transverse section by the appearance of walls b-b which divide the two segments into cells of unequal size. The walls b-b are approximately parallel and meet the primary wall a-a towards opposite ends. The third series of walls c-c meets the other walls a-a and b-b as shown in Diagram I.

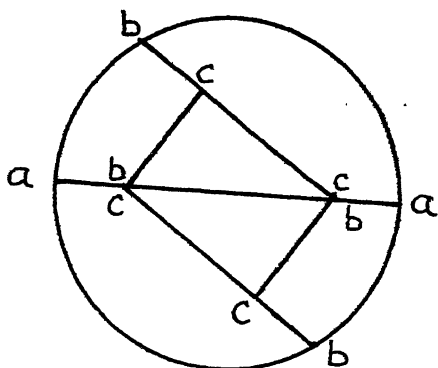


DIAGRAM I.

This results in the formation of centrally placed cells, surrounded by peripheral ones. The latter from now on divide only radially, so giving rise to the one-layered wall, while the former divide in all planes and eventually produce the mass of sperm cells. The central cells from the first stand out clearly in stained sections, having large nuclei and very dense cytoplasmic contents. The spermatogenous tissue can thus be distinguished at a very early stage from those cells which constitute the wall, since in the latter the cytoplasm is much vacuolated and the nuclei somewhat smaller.

The lower of the periclinal divisions, as seen in longitudinal section, occur while the apical cell is still actively cutting off segments. According to Campbell (13, pp. 196-7), "The number of these segments is limited, in *Funaria* not often exceeding seven, and after the full number has been formed the apical cell is divided by a septum parallel with its outer face into an inner cell, which, with the inner cells of the segments forms the mass of sperm cells, and an outer cell which produces the upper part of the wall."

The present writer finds that the apical cell in *Cyathophorum* shows no such division, but apparently retains the ability to divide further. As already noted the spermatogenous tissue can be recognised early, and when this is apparently all formed, and much sub-divided, the apical cell is still intact (Figs. 20-21). In fact, the fully mature antheridium usually shows one or two divisions at the apex directly resulting from the action of the apical cell (Fig. 23). These are not isolated instances but were seen in dozens of antheridia.

This appearance is explainable in two ways: Either the periclinal walls do not form in the last few segments nearest the apex, or else the apical cell cuts off segments subsequently to the formation of the last of the central cells. Whichever interpretation is accepted, the fact remains that the apical cell functions to a late stage and can be recognised even in the mature antheridium.

The spermatogenous cells divide very regularly in all planes, and the original walls separating adjacent primary segments can be recognised at a late stage (Fig. 22). However, eventually all the cell walls break down and the mature antheridium consists of a large number of sperms embedded in mucilage, which still shows traces of cellular structure.

The stalk is relatively long. In median longitudinal section the original divisions due to the "two-sided" apical cell can be traced, although with increase in age the regularity of the early segmentation is much disturbed. However, it is quite clear that the stalk is derived from segments cut off from the two-sided apical cell, and not due to a series of transverse divisions, formed by the original papilla (as in *Andreaea*) prior to the setting apart of the two-sided apical cell. The wall is one layered and its cells, except for a few at the apex, contain chloroplasts.

Ripe antheridia open in a few moments if placed in water or very dilute sugar solution (0.4%)—the latter was found to cause much more vigorous movement in the sperms when they were attempting to escape from the mass of mucilage in which they were extruded from the antheridium.

A rupture occurs between the opercular cells, of which there are several, and the complete contents of the antheridium emerges through a constricted opening. This mass of sperms, still enclosed in mucilage is often two or three times the length of the antheridium from which it came, giving an indication that the swelling of the mucilage, by inhibition of water, is one of the main factors causing the bursting of the antheridium.

While the lower part of the contents is still within the antheridium the sperms at the upper end begin to show a characteristic gyrating movement. The mucilage gradually thins out and the sperms are set free. The form of the sperm is the usual one for Mosses. There is a distinct vesicle, and the two very long cilia, so characteristic of the Bryophyta as a whole, are attached to a densely staining nuclear portion which forms the main body of the sperm.

DEVELOPMENT OF THE ARCHEGONIUM.

The following description is based on evidence obtained from sectioning over eighty archegonial tufts, the majority of the stages figured being observed frequently.

Like the antheridia, the archegonia arise from surface cells at the apex of the female branches. A surface cell protrudes and becomes more or less papilliform. (This papilliform nature is much more marked than in the antheridium initial.) The first wall formed in it shows a little variation, but generally it is very oblique, so cutting off a two-sided apical cell, as in the antheridium. (Figs. 25-26.) The variation is in the degree of slanting of this first wall, which may range from almost vertical to practically transverse. In the latter case a second wall meeting the first one has to form before one can speak of a "two-sided" apical cell. There appears to be no wall cutting off a basal cell from the archegonial mother cell as described by Campbell (13), Goebel (17) and Gayet (16). In this respect the development in *Cyathophorum* agrees with that given for *Mnium cuspidatum* by Holferty (21).

The two-sided apical cell cuts off from three to six segments in the same manner as in the antheridium before the characteristic development of the archegonium from a so-called "three-sided" apical cell commences. The change from a two-sided to this "three-sided" apical cell takes place when a wall is formed in the former, which is more nearly vertical than the walls which precede. As noted by Holferty (21) this is an abrupt change and immediately gives the "three-sided" apical cell. (Figs. 29-30.) This now divides by a transverse wall, so forming a terminal and an inner cell (Fig. 31, t and i). This inner cell is the first of the axial row in both Liverworts and Mosses, while all the tissue below goes to form the pedicel. There is some disagreement as to the parts played by the terminal cell and the inner cell in the later history of the archegonium. This concerns in particular the origin of the axial row, but for the sake of continuity the discussion of these views is held over till later and the development as found in *Cyathophorum* is continued.

The inner cell (Fig. 31 i) divides transversely, giving rise to a lower and an upper cell (Fig. 35 l-p). The upper cell is the primary canal initial or mother cell of the canal row, while the lower is the primary ventral cell. The latter appears to divide fairly late as Bryan (11) also states. Fig. 37 shows a stage with five neck canal cells and the primary ventral cell still undivided. However, there appears to be some variation here as cases have been noted by the present writer where the egg cell and the ventral canal

cell are clearly to be recognised when there are no more than four or five neck canal cells. Seeing that the mature archegonium has as many as fourteen of these, this may be taken as a comparatively early separation of the egg.

The apical cell at this stage in the development is referred to by other writers as a "three-sided" apical cell. It must be remembered that in addition to segments cut off parallel to the three lateral faces, this cell also cuts off segments parallel to its base. There are, therefore, four cutting faces, and the cell should, strictly speaking, be termed "four-sided."

The "three-sided" apical cell cuts off segments parallel to the three lateral faces, and also parallel to the base. The former series divide by vertical walls, so forming six rows of cells which make up the wall of the archegonial neck, while the latter add to the axial row of neck canal cells. Both the cells of the neck and those of the axial row may undergo intercalary divisions so adding to the length of the archegonium. (Fig. 38.)

In the vicinity of the egg the wall becomes two or three-layered, so forming the venter, which merges with the massive pedicel. This latter owes its origin first to the activity of the two-sided apical cell, and secondly to subsequent divisions in the original segments.

There are two sources of evidence to show that the apical cell does add to the series of neck canal cells by cutting off segments parallel to its base. The first is shown in Fig. 39. The outline of the original apical cell is clearly seen, and the cell cut off by the wall parallel to its base obviously adds to the canal row. The second source of evidence is in seeing the mitotic figure of the apical cell lying in such a way that the resulting wall will be parallel to its base. (Fig. 38.) Figs. 37-38-39 are not isolated examples, but were found about eight times.

The apical cell continues to cut off segments adding to the length of the neck till a late stage, but according to Holferty (21) "the last divisions for this purpose are always intercalary." However, in the present study no mitotic figure was secured to prove that intercalary division took place, after the apical cell had ceased functioning, so that there must remain some doubt on the point in regard to *Cyathophorum*. The mature archegonium (Fig. 40) consists of the usual long spirally-twisted neck, two-layered venter and massive pedicel. The axial row consists of from ten to fourteen neck canal cells, the ventral canal cell, and the egg—the latter in all cases observed being much larger than any other cell of the axial row. When mature, the archegonium opens at the apex, the terminal cells diverging fairly widely and being sometimes detached altogether. At a stage immediately before the neck opens the canal row has practically disintegrated. The walls between the cells disappear, so that finally, when the neck does open, there is a passage to the egg. This may be filled more or less with mucilage, derived from the disintegrated canal cells, a certain amount of which appears to be extruded when the archegonium opens.

DEVELOPMENT OF THE SPOROAGONIUM.

(a) *Embryo*. Very early stages as already noted are difficult to kill and fix, due to the large size of the cells and the extremely delicate nature of the cell walls. The earliest stage found (Fig. 41) consists of two much-elongated cells. The succession of divisions appears different from those in *Andreaea* and *Funaria*, where the second wall occurs in the epibasal cell and strikes the basal wall in such a way as to cut out an apical cell with two cutting faces.

In *Cyathophorum* successively older embryos (Figs. 42 and 44) show that a series of transverse divisions occurs to give a very elongated embryo, before the apical cell appears. Eventually, however, an oblique wall forms in the uppermost cell, which now constitutes the two-sided apical from which the embryo grows for a very long time. The actual setting apart of the apical cell was not observed. The embryo as it grows becomes embedded in the tissue of what was the pedicel of the archegonium, now very much swollen. This embedding of the embryo takes place so completely at a later stage that the question is raised as to whether it is due solely to the upgrowth of the underlying gametophytic tissue, or to some process of digestion on the part of the young sporogonium itself. Owing to the manner of the earliest cell divisions in the embryo, the limits of the foot are difficult to define, but in the later stages the greater part of the absorbing portion of the embryo does not belong to the true foot at all, but has come from the apical cell.

Longitudinal sections show that the apical cell cuts off segments in very regular succession as usual in Mosses. At first thought it is difficult to picture how a two-sided apical cell can cut off segments in such a way as to build up a solid cylindrical embryo. A detailed study of a large number of longitudinal and transverse sections makes this clear. In this study some eighty embryos were sectioned. A close series of figures, derived from a large number of embryos, setting forth the development as seen in transverse section is given by Figs. 50-60. In addition, Fig. 46 a-k shows serial sections taken at intervals of eight microns through the upper portion of one embryo. Any longitudinal section shows that periclinal walls appear early (Figs. 43-44). (In these particular embryos distortion due to killing and fixing has occurred—see section on Material and Methods). A study of transverse sections, however, shows that they are preceded by anticlinal walls (Fig. 51 b-b,) dividing the original segments. These walls are followed by others which are obliquely anticlinal, represented c-c in Figs. 52-58. There is considerable variation as to whether the walls c-c meet the primary wall a-a or the wall b-b (Fig. 54). The next walls (d-d in Figs. 56-58) meet the walls b-b in such a way as to cut off a series of central cells, the endothecium, from peripheral cells or amphithecium. In *Funaria* the early divisions are somewhat different (Campbell 13). The second series of walls is usually periclinal, thus separating the endothecium and amphithecium at a slightly earlier stage. Campbell (*loc. cit.*) notes that this is not invariable for *Funaria*. Judging by the fact that only one instance (Fig. 47) was found in the whole series of numerous embryos studied, it would appear that for

Cyathophorum this early separation of the endothecium is an uncommon variation, and that normally the separation is not complete until the third series of walls is formed. This is also the case in other Bryineae which have been described by other writers.

When the endothecium has been separated, the structure shown in Fig. 59 remains constant throughout a considerable length of the upper region of the embryo (viz. for a distance of 96–120 microns in the particular examples studied). This structure as seen in longitudinal section is shown in Fig. 48. The embryo as a whole at this stage is shown *in situ* in Fig. 49. It has much increased in size and the swelling that eventually causes the rupture of the venter is evident. For purposes of convenience the account of the development of the young capsule is carried on from this point.

(b) *Young Capsule*. The nuclei of the four cells of the endothecium at this stage are very large and stain deeply. (Figs. 59–60.) There is slight variation in the divisions which follow on from the stage shown in Fig. 59, but by far the most usual case is for the amphithecium to become separated into two layers by periclinal divisions. (Figs. 60–61.) Occasionally the endothecium begins to divide before the amphithecium, but this is quite unusual, and as a rule by the time the former begins to divide the amphithecium is at least two and maybe three or four-layered.

The endothecial cells now subdivide to give a group of four central cells (c. Fig. 63) surrounded by about eight peripheral cells (p. Fig. 63). The regularity of the divisions is usually disturbed, and instead of the theoretical eight there may be ten or eleven cells in this layer (Fig. 64 p). It is from these cells that the archesporium and the inner spore sac develop, the four central cells subdividing further to make up the tissue of the columella. The peripheral cells (p. Fig. 64) divide first by radial, and then by periclinal division, into inner and outer cells. The inner cells constitute the inner spore sac (i.s. Fig. 77)—actually the outer layer of the columella—while the outer cells by a number of further radial divisions form the archesporium (Fig. 77 sp.).

As seen in transverse section the amphithecium consists in its primary stage of eight cells (Fig. 59). The first divisions in these cells are usually periclinal, cutting off smaller inner cells from larger outer ones (Fig. 60). These periclinal divisions separate what will become the wall of the capsule from the outer spore sac. The cells of the latter divide first radially (Figs. 62–64) and then periclinally so that at this stage the spore sac is two layered (Fig. 78 o.s.p.s). Further periclinal divisions set in as a rule, giving an outer spore sac which may be three or four cells thick when mature (Fig. 82).

Longitudinal sections of embryos of increasing ages show how the capsule originates. Figs. 48–49 show that some distance behind the apex the cells undergo rapid division, resulting in a swelling of the young sporogonium at this point (Fig. 49 c). This swollen region is the forerunner of the lower portion of the capsule, while the tissues above this swelling give rise to the remainder of the capsule and operculum, although, of course, its limits cannot be defined as the embryo is still growing fast. The foot region at this

stage (Fig. 49) is relatively very large, and in fact it does not further increase much in size even in the mature sporogonium. The outer layer of cells has obvious nuclei and rather dense contents, no doubt due to the rapid intaking of food from the gametophore, while the central cells are elongated. (Figs. 49 and 71.)

Where the young sporogonium emerges from the much swollen "venter," it shows a distinct collar, very obvious in longitudinal sections (Fig. 67, semi-diagramatic). This collar appears to function in the forcing off of the calyptra—helped of course by the general elongation of the young sporophyte—and is still evident in the mature sporogonium where the seta enters the vaginula. (Fig. 68.) Rapid division in the tissues immediately above this collar initiates the formation of the seta which carries the young capsule, with its enclosing calyptra, upwards. (Fig. 68.)

Transverse sections taken through the young capsule show the development of the archesporium as already described, and also the origin of the air space. The layer of cells (1. Fig. 77) immediately outside the outer spore sac, shows very characteristically as noted by Campbell (13). They are narrow radially but rather extended laterally, and it is between these cells and the spore sac that the air space develops. The walls of the cells which will border the air space when it forms take the stain very deeply, enabling the position of the space, as seen in longitudinal section (Fig. 69) to be traced for some distance above the point where the cells have actually come apart. By the time the air space is formed the outer spore sac is two or even three layered, but the sporogenous tissue still remains in its one-layered condition for a time. (Fig. 77.) Eventually, when the full extent of the air space has formed and the general lay-out of the capsule has been completed, the fertile tissue becomes two layered—divisions appearing first at the base and extending upwards. (Figs. 72-74.) The result of these divisions is to produce the spore mother cells which come apart from one another and lie free in the space between the inner and outer spore sacs. Here they undergo the usual "tetrad" division, each producing four spores. (Fig. 84.)

A transverse section of the seta at this stage shows that the conducting strand has developed. In transverse section this is seen to consist of a few thin-walled cells, while the walls of the cortical and epidermal cells in the seta region become much thickened especially at the angles, and turn brown. (Fig. 80—full thickness of walls in cortex not shown.)

In *Cyathophorum* the operculum presents a characteristic appearance in longitudinal section. The apical cell functions for a very long time as already mentioned, and can frequently be recognised even in a mature capsule. (Fig. 76.) From the apex a central "core" of tissue with very regular divisions extends down to the top of the columella. The peristome arises from the fourth or fifth layer of cells from the outer margin of the operculum. In longitudinal section this layer is seen to consist of cells whose radial walls are much extended. (Fig. 81.) It is by thickening of these radial, and also peripheral, walls that the peristome teeth are formed.

Thickening is first seen on the peripheral walls and it gradually extends inwards along the radial ones until the lumen of the cell is practically filled—the nucleus remaining obvious till a very late stage in the process. (Fig. 75.) From this stage on it was found very difficult to get complete sections through the peristome, as the greatly thickened teeth usually tore away from the thinner walled tissues below.

At the junction of the operculum and theca there appears a ring-like depression which runs completely round the capsule. This marks the position of the annulus. In *Cyathophorum* the form of the annulus is rather different from that figured by Campbell (13) for *Funaria*. In longitudinal section there is one cell very much larger than those above and below, which still shows its nucleus and contents after the surrounding cells have lost theirs. Thus, as thickening of the walls of this cell occurs late, and is never well developed, it represents a place of weakness where the operculum joins the theca. (Fig. 81.) Eventually when the capsule is mature the rupture occurs at this level, and the operculum is shed. It seems that the peristome teeth must be effective in forcing off the operculum and causing the rupture of the annulus. No doubt the general drying and collapse of the central tissues will help, but the main factor seems to be the extremely hygroscopic nature of the teeth which respond to humidity changes even when protected by the operculum. The fact that when the operculum in a mature capsule is removed gently, the teeth of the peristome immediately curve outwards as if they had been held under tension, is further evidence in the same direction.

The apophysis in *Cyathophorum* is very poorly marked. Its cells are loosely arranged with wide air spaces, and except for the central conducting portion most of them have chloroplasts. Stomata are present on the surface, thus allowing communication between the atmosphere, the intercellular spaces and the actual air space of the capsule.

At the stage when the sporogenous cells are undergoing their final division the columella is very densely stocked with large starch grains, and the cells bordering on the spore mass appear to function as a "tapetum." Their nuclei are large and the whole contents stains deeply. (Fig. 84) At a somewhat earlier stage, when the fertile tissue is in the condition shown in Fig. 70, starch grains are much less abundant and very much smaller. There are also fewer chloroplasts in those cells bordering on air spaces than in the later stages. Thus it seems reasonable to suppose that the bulk of the starch is the result of photosynthesis on the part of the sporogonium itself.

The calyptra is not large compared with that in some Mosses, and its development can be easily traced. The venter of the fertilised archegonium undergoes a large amount of secondary cell division and eventually becomes bell-shaped with a distinct incurved base. (Figs. 65–68.) A transverse section shows the outer cells to be much larger than those bordering on the space containing the young

sporogonium, and also much less densely stocked with cytoplasm. With further growth of the sporogonium the venter ruptures about its base and is carried away on top of the young capsule.

(c) *Older Sporogonium*. The general outline of the capsule with the operculum still attached is shown in longitudinal section in Fig. 70. The wall is four or five cells thick and the mass of spores occupies a larger space than before. In fact, the growth of the fertile tissue is such that the air space is practically obliterated except in the basal region. The columella is massive and shows signs of tearing away from the tissues of the operculum. This it does later and the upper part collapses leaving the lower half standing as a pillar surrounded by the spore mass. The outer spore sac persists at the base for a fairly long time, but when the columella breaks down it is reduced to a membrane in the upper part of the capsule. (Fig. 88.) Eventually the operculum is shed and the peristome teeth commence to excavate the mass of green spores. The peristome consists of an outer circle of sixteen heavy teeth with distinct thickenings in the form of bars, and an inner circle of the same number of V-shaped teeth alternating with cilia.

Brotherus (10) figures the teeth of *Cyathophorum bulbosum*, but no cilia corresponding to the type given by him were found by the present writer. Similarly his figure for the capsule of the same species is of quite different shape from that described in the present paper. It seems that the outer series of teeth is mainly responsible for excavating the spores by hygroscopic movements. If a mature capsule is mounted upright and observed under the microscope, the teeth can be made to act by breathing gently on them. When this is done those in the outer circle curve inwards and force their way between those of the inner series down into the spore mass. After a time (no doubt when the humidity has fallen again) the teeth straighten, and by so doing rasp their bar-like thickenings against those of the inner teeth and cilia. This is a very jerky motion and causes the dry spores adhering to the teeth to be scattered.

The seta is short and undergoes no hygroscopic movement as it does in some mosses (e.g. *Funaria*). As regards the "foot" region of the seta, the usual statement (e.g. Campbell 13) is that the base of the seta "grows down" into the tissue of the gametophore, from which it of course obtains nourishment. In *Cyathophorum*, as already noted, the embryo, even before the venter is burst, is as much embedded in the tissues of the gametophore as it ever is. The seta does not "grow down," as its lower absorbing portion is already deeply embedded.

The final stage comes very much later when the seta breaks across the top of the vaginula and the whole empty and withered capsule is shed.

DISCUSSION.

(a) *Antheridium*. The development of the antheridium is very similar to that described for other Mosses and differs only in slight details. The first of these is the very early setting apart of the

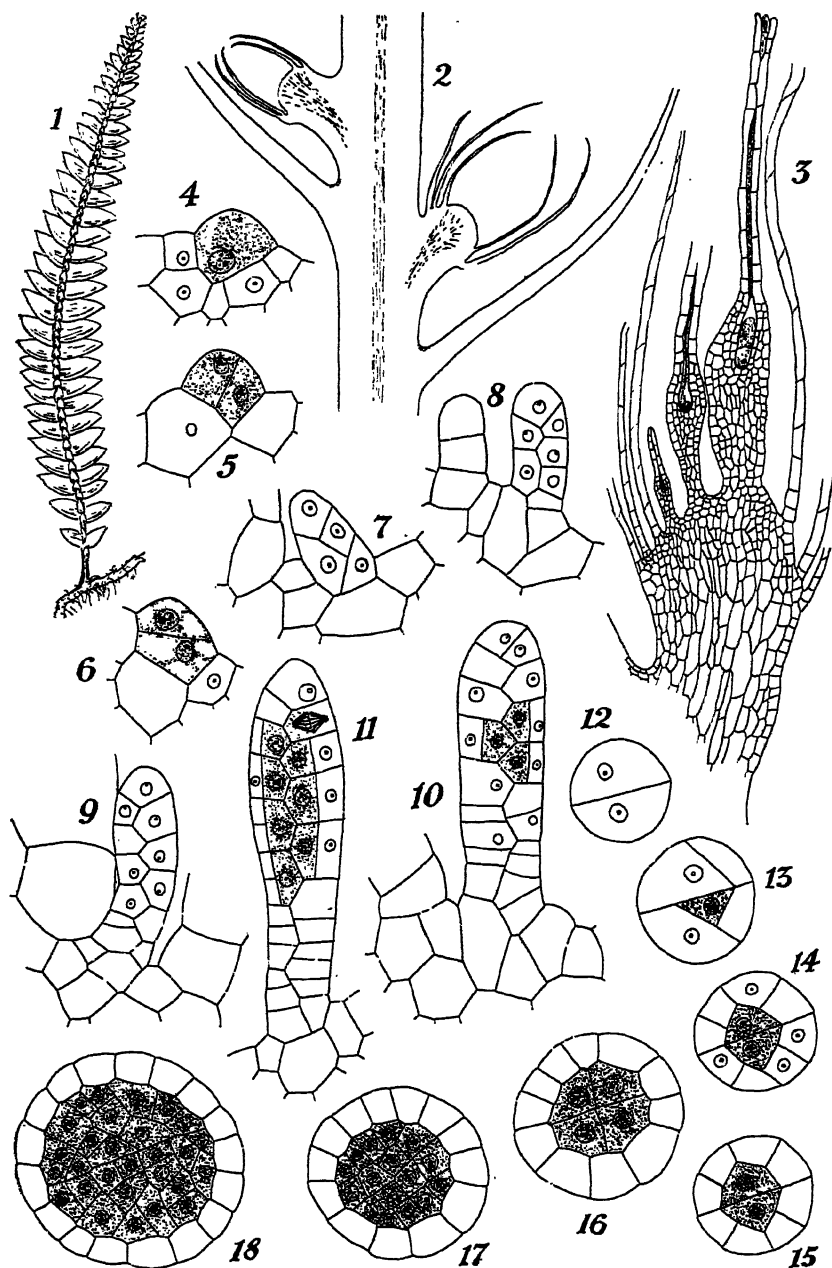


FIG. 1.—Gametophore of *C. bulbosum* ventral view. Nat. size. FIG. 2.—Diagram of L.S. main stem showing lateral sex branches, sex organs omitted; $\times 30$. FIG. 3.—L.S. archegonial branch; large archegonium shows a young embryo; $\times 70$. FIGS. 4–9.—Development of antheridium as seen in L.S. before advent of periclinal division; $\times 570$. FIGS. 10–11.—Ditto, showing advent of periclinal division; $\times 570$. FIGS. 12–18.—Advent of periclinal division as seen in transverse section; $\times 570$.

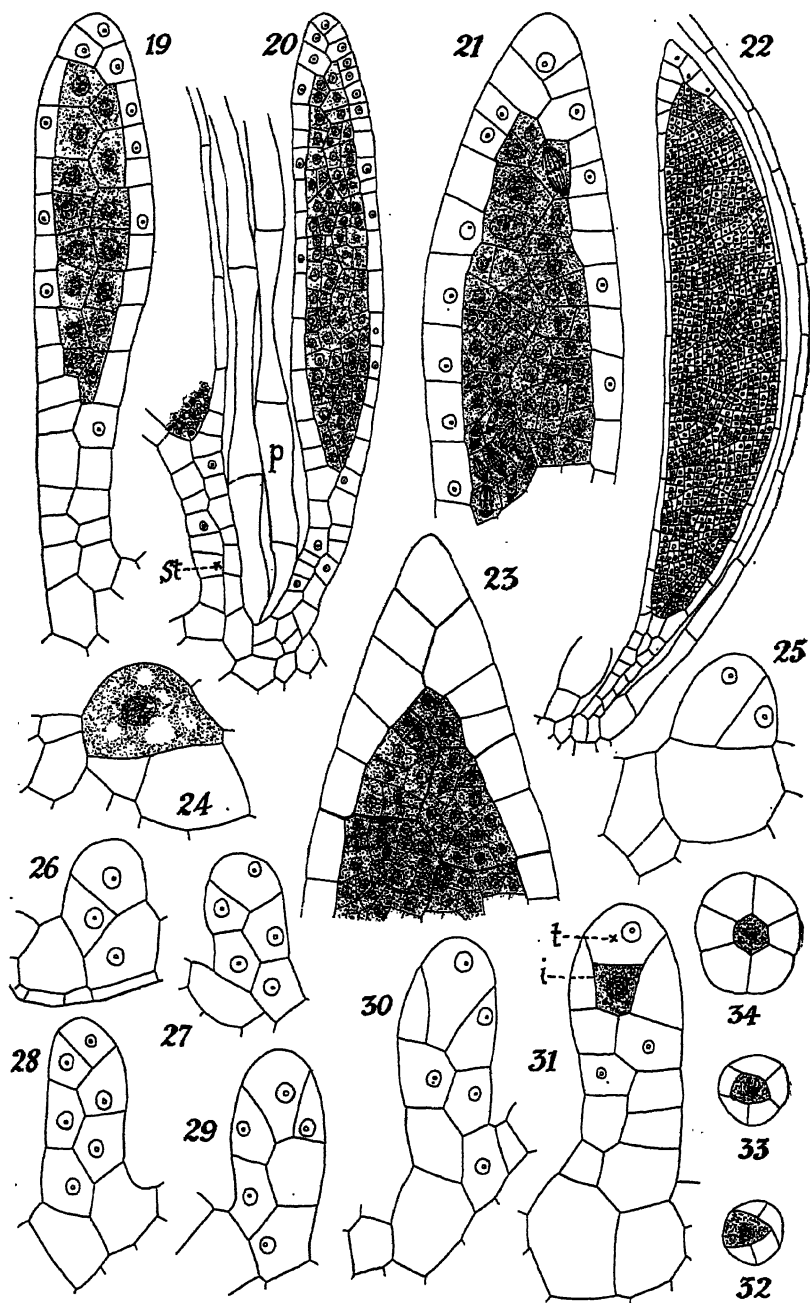


FIG. 19.—L.S. antheridium; fertile tissue undivided; $\times 570$. FIG. 20.—Ditto, fertile tissue sub-divided; p.: paraphyses; st.: stalk of mature antheridium; $\times 290$. FIG. 21.—Ditto, showing all nuclei in one segment dividing; $\times 570$. FIG. 22.—L.S. nearly mature antheridium; $\times 150$. FIG. 23.—Ditto of apex to show apical cell still intact; $\times 570$. FIGS. 24-28.—Development of archegonium from "2-sided" apical cell; $\times 700$. FIGS. 29-30.—Formation of "3-sided" apical cell; $\times 700$. FIG. 31.—Division of apical cell: t: terminal cell; i: inner cell; $\times 700$. FIG. 32.—T.S. "2-sided" apical cell; $\times 350$. FIG. 33.—Ditto, "3-sided" apical cell; $\times 350$.

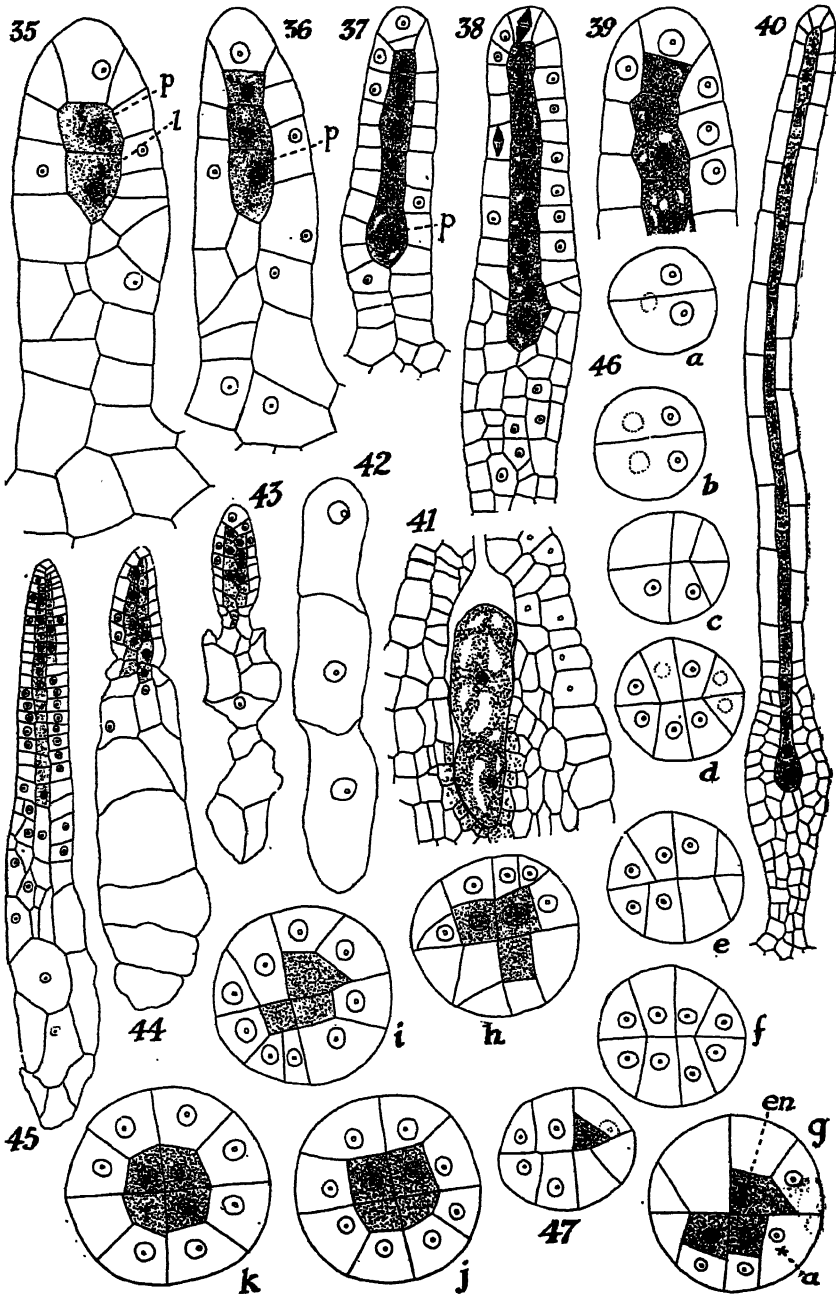


FIG. 35.—L.S. archegonium; inner cell divided to give primary ventral cell (l) and primary canal initial (p); $\times 700$. FIG. 36.—Ditto, showing primary ventral cell (p) and two neck canal cells $\times 700$. FIG. 37.—Ditto showing intercalary division; primary ventral cell (p) still undivided $\times 350$. FIG. 38.—L.S. older archegonium showing division in neck canal wall, and apical cell; $\times 350$. FIG. 39.—L.S. apex mature archegonium with apical cell adding a segment to the canal row; $\times 700$. FIG. 40.—L.S. mature archegonium; $\times 175$. FIG. 41.—L.S. embryo in venter showing first wall; $\times 300$. FIG. 42.—L.S. embryo in 3-celled stage; $\times 300$. FIGS. 43-45.—L.S. older embryos; $\times 150$. FIGS. 46 a-k.—Serial T.S. through one embryo from apex; en: endothecium. a: amphithectium; $\times 605$. FIG. 47.—T.S. showing variation in

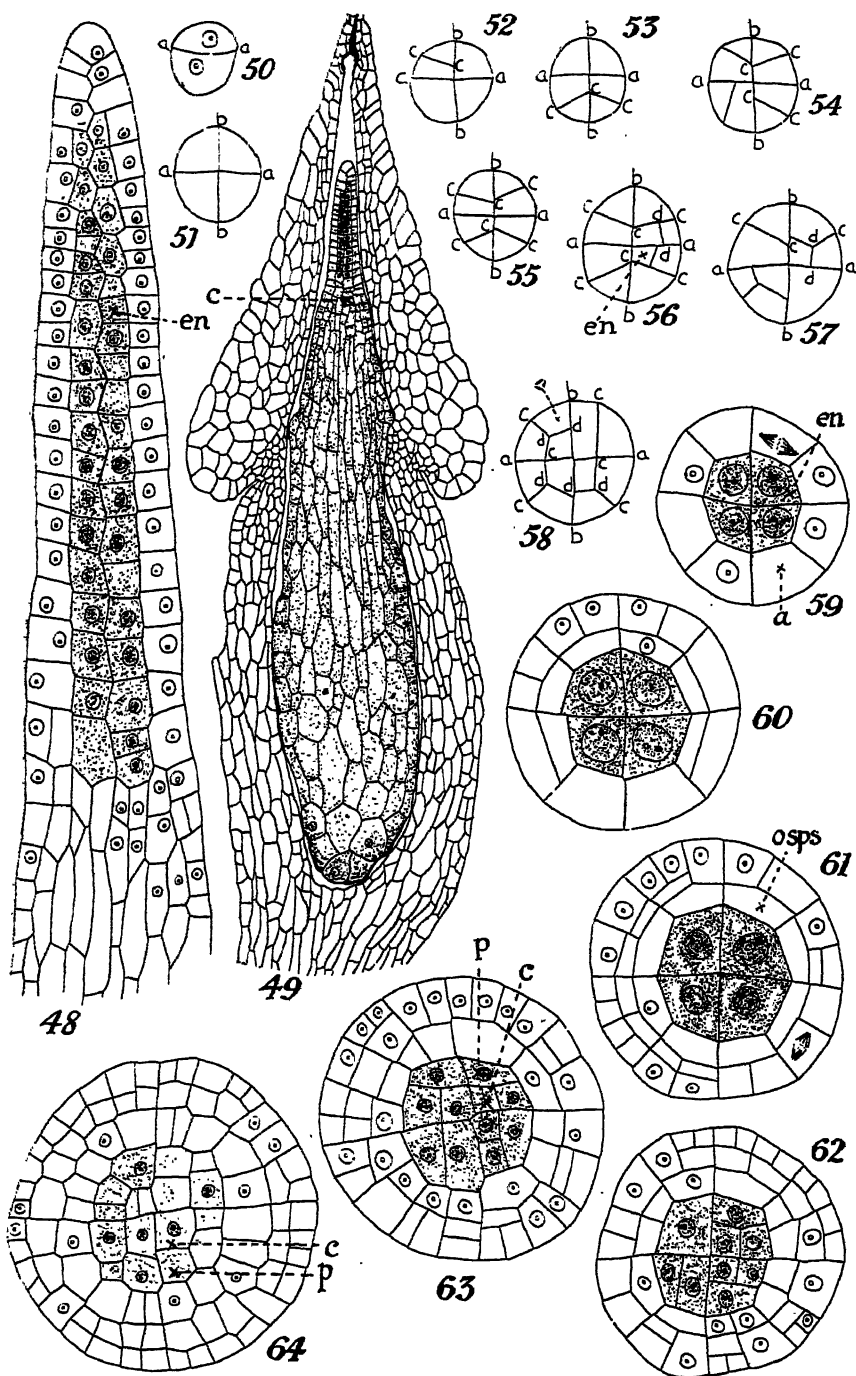
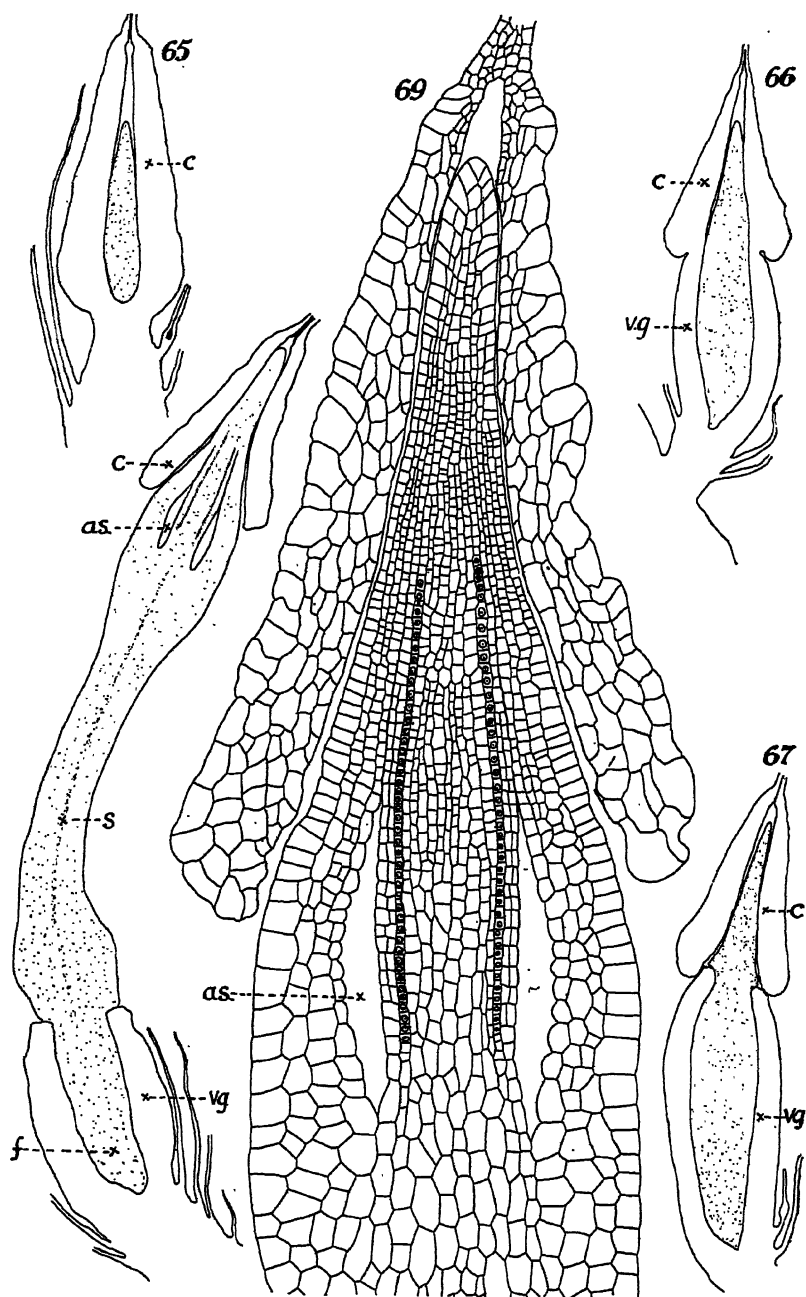


FIG. 48.—L.S. apex of sporogonium; en: endothecium; $\times 300$. FIG. 49.—L.S. complete sporogonium; $\times 75$. FIGS. 50–59.—Transverse sections of sporogonia showing development of endothecium (en) and amphithecium (a); $\times 400$. FIGS. 60–64.—Division of amphithecium and endothecium; o.s.p.s.: outer spore sac, p: peripheral cells; c: central cells; $\times 400$.



FIGS. 65-67.—Diagrams to show development of sporegonium, calyptra, etc.; c: calyptra, vg.: vaginula. FIGS. 65 and 66.— $\times 50$. FIG. 67.— $\times 35$. FIG. 68.—L.S. very young capsule. c: calyptra, s: seta, f: foot, vg: vaginula; $\times 37$. FIG. 69.—L.S. upper portion of young capsule (cf. Fig. 68), not perfectly median at apex; $\times 150$.

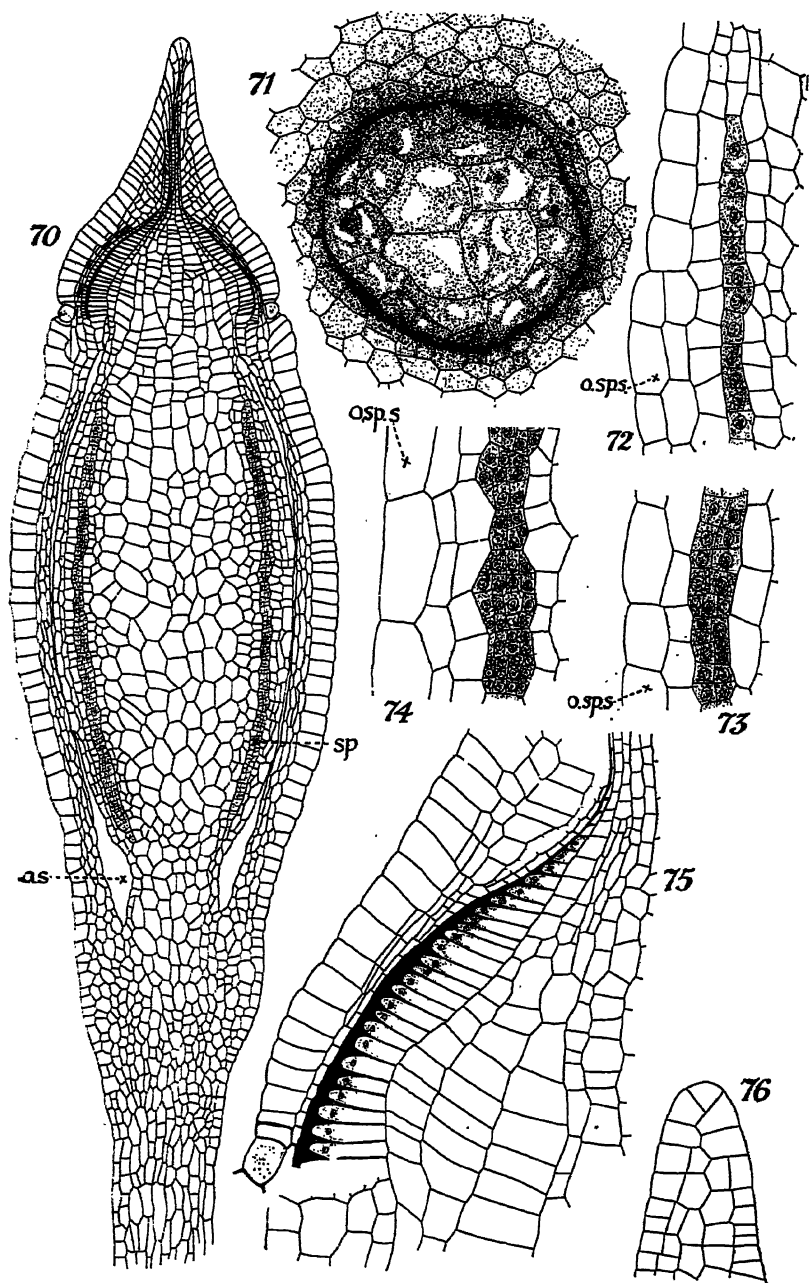
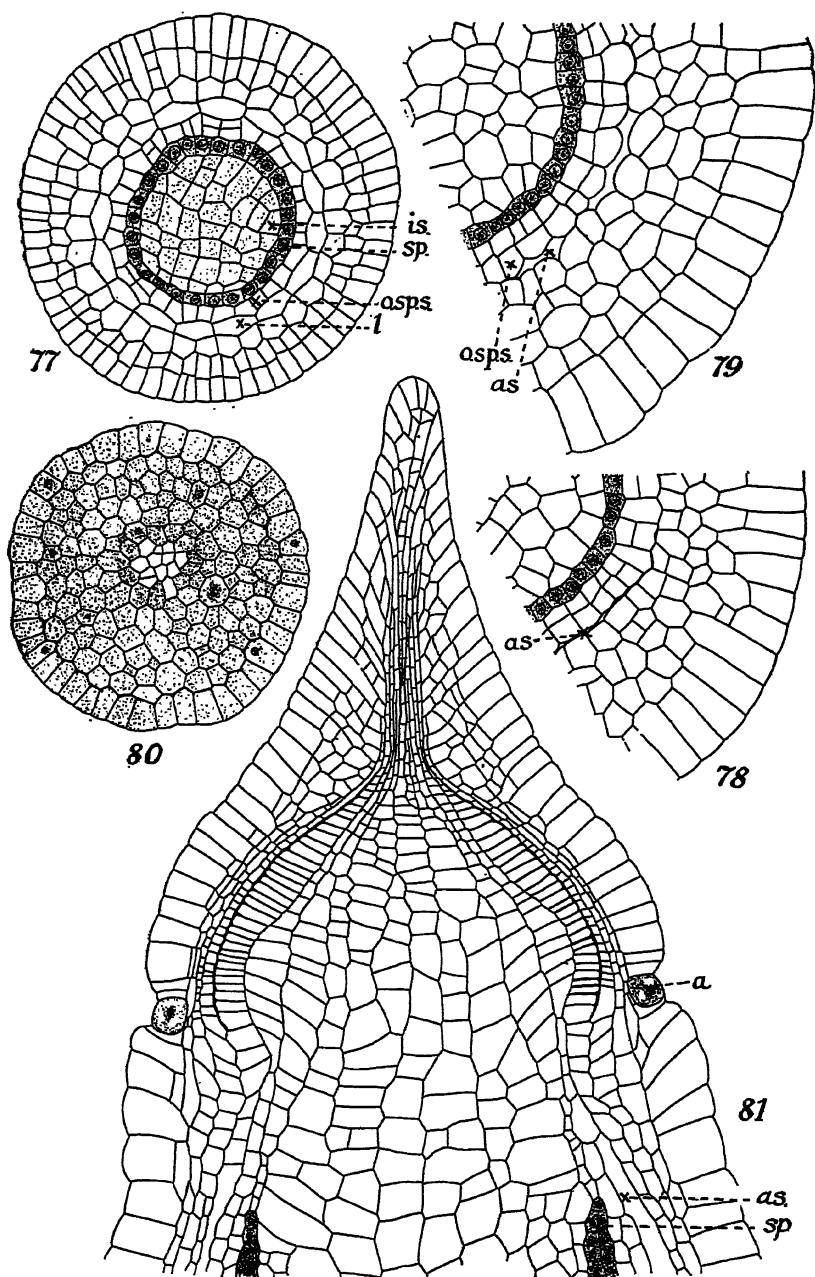


FIG. 70.—L.S. immature capsule; a.s.: air space, sp: sporogonial tissue; $\times 50$. FIG. 71.—T.S. foot, and surrounding gametophytic tissue. N.B., dense cytoplasm; $\times 172$. FIGS. 72-74.—Division of sporogenous tissue; o.s.p.s.: outer spore sac; $\times 300$. FIG. 75.—L.S. portion of peristome showing one tooth; $\times 150$. FIG. 76.—L.S. apex of capsule showing apical cell; $\times 300$.



FIGS. 77-79.—T.S. young capsule showing development of air space (a.s.): o.sp.s.: outer spore sac, i: inner wall of capsule, sp.: sporogenous tissue; $\times 300$. FIG. 80.—T.S. seta with conducting strand; $\times 200$. FIG. 81.—L.S. upper portion of immature capsule; a.: annulus, a.s.: air space, sp.: sporogenous tissue; $\times 100$.

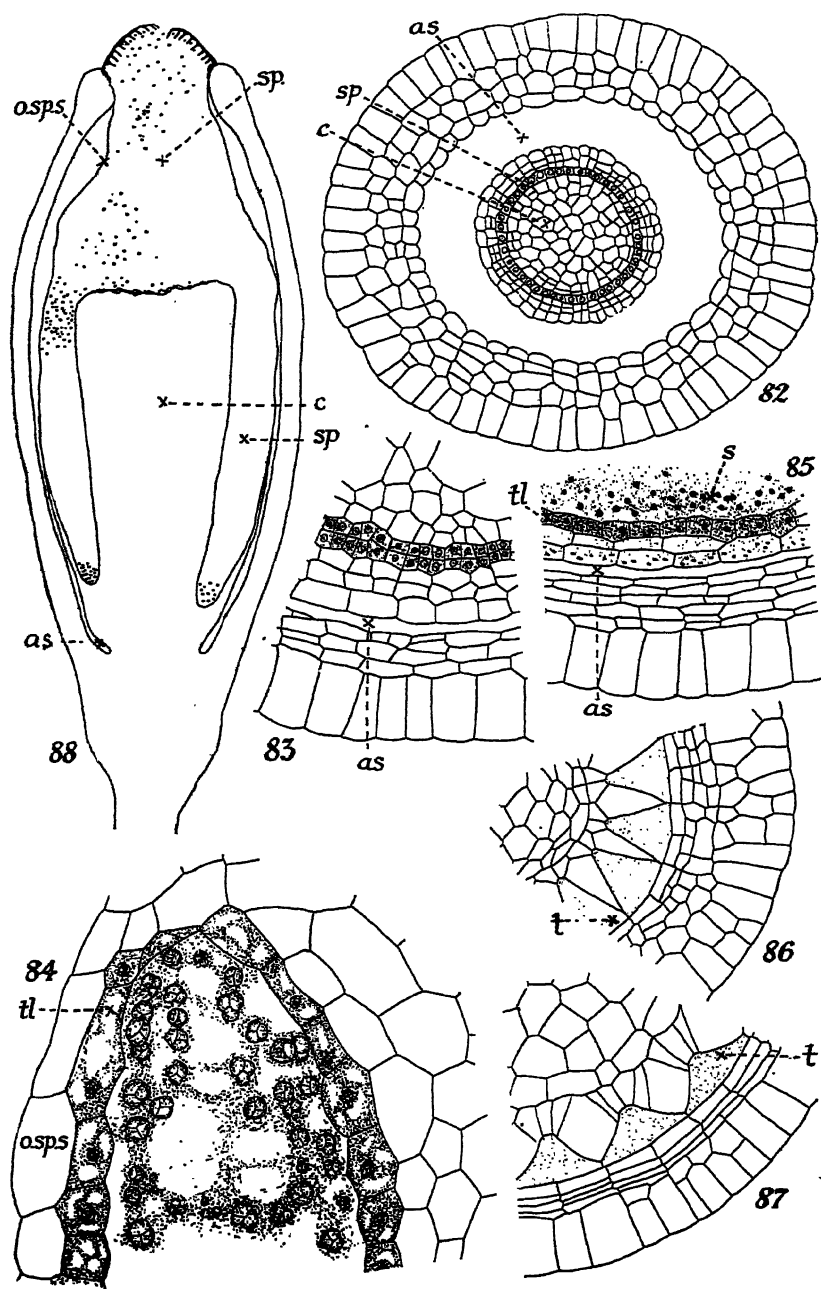


FIG. 82.—T.S. Immature capsule; a.s.: air space. c.: columella; sp.: sporogenous tissue; $\times 150$. FIG. 83.—Ditto, sporogenous tissue dividing; $\times 150$. FIG. 84.—L.S. spore sac with spore "tetrads"; o.s.p.s.: outer spore sac; tl.: "tapetal" layer $\times 300$. FIG. 85.—T.S. portion of mature capsule; s.: spores, a.s.: air space, tl. "tapetal" layer; $\times 150$. FIG. 86.—T.S. peristome before operculum is shed; t. tooth; $\times 150$. FIG. 87.—Ditto, near base of peristome; $\times 150$. FIG. 88.—L.S. mature capsule, operculum shed; a.s.: air space, c.: columella; sp.: spore mass, o.s.p.s.: outer spore sac reduced to a membrane; $\times 30$.

two-sided apical cells, before any pedicel is apparent. (This also occurs in *Mnium*, Holferty 21.) The segmentation of the antheridium to cut off central spermatogenous cells is somewhat different from that described by Goebel (17, p. 13); and Ruhland (29, p. 66). The succession of walls given by them is shown in Diagram II. In the species described by these authors the walls b-b both meet the primary wall a-a at the same point. Similarly with the third series c-c. In *Cyathophorum* (see Diagram I) the walls b-b are approximately parallel and meet the primary wall towards opposite ends. In *Funaria hygrometrica* (Campbell 13) the succession of walls corresponds to that given for *Cyathophorum* (Diagram I). The account of the apical cell has already been given.

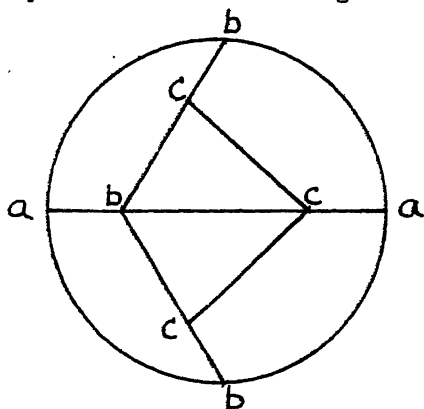


DIAGRAM II.

(b) *Archegonium*. As already noted, there appears to be some confusion as to the exact manner in which the archegonium grows and forms the axial row. Campbell, Goebel, Holferty and others distinguish the archegonium of the Musci from that of the Hepaticae by the fact that the cover cell is active in the former, adding both to the cells of the neck and to the axial row. It thus seems fairly clear that in Musci the archegonium grows in length as a result of segmentation by the three-sided apical cell. How far this apical cell or cover cell is responsible for the cells of the canal row is however not so clear.

According to Campbell (13) in *Funaria hygrometrica* the terminal mother cell of the young archegonium divides transversely, giving rise to an upper cell, corresponding to the cover cell of the Liverworts, and an inner cell which produces the primary neck canal cell, the egg and the ventral cell. The cover cell functions as an apical cell cutting off lateral segments which give rise to the outer cells of the neck, and also segments parallel to the base to form the cells of the neck canal. Thus in this account all the neck canal cells arise from the apical cell, with the exception of the primary neck canal cell. This appears to persist as the lowest of the cells in the canal row lying immediately above the ventral canal cell. Campbell (*loc. cit.*) states definitely that "the canal cells so far as could be determined do not divide after they are first formed." In *Cyathophorum* however this is evidently not the case.

G. M. Holferty (21) for *Mnium cuspidatum* gives the same general sequence of events except that he holds that the primary neck canal cell undergoes intercalary divisions. The cells cut off from the apical may also undergo intercalary division. Thus here the uppermost cells of the neck canal series are different in origin from those towards the base.

G. S. Bryan (11) in his work on *Sphagnum subsecundum* finds no evidence that any cells of the canal row are derived from the apical cell—the whole series being due entirely to intercalary divisions of the primary neck canal cell. Thus *Sphagnum* appears to be one of the Musci in which the archegonium shows distinct Hepatic characters.

Gayet (16) holds that growth of the archegonium in both Musci and Hepaticae is terminal, but that the apical cell does not add to the canal row. As noted by Bryan (11), this view appears to be rather a contradiction.

The present investigation supports the view advanced by Holferth (21) viz., that the neck canal cells are derived in part from the apical cell. Intercalary divisions definitely do occur, adding further to the length of the neck.

(c) *Sporogonium*. As already noted, the early stages in development of the sporogonium of *Cyathophorum* differ from those in *Andreaea* and *Funaria*. The very elongated embryo resulting from a number of transverse divisions offers some analogy with the embryos of *Sphagnum* (Campbell 13) and even of *Fossombronia* (Humphrey 22). Of course such a comparison is very superficial and applies only to the first few divisions. Once the two-sided apical cell is formed this similarity ceases and development follows the usual course for the true mosses. In the development of the sex organs and the sporogonium as given above, it is seen that there are no fundamental differences between *Cyathophorum* and such other mosses as have been described. There are, however, differences in detail, as is only to be expected in such a large group.

As regards the embedding of the lower part of the seta in the tissue of the gametophore, Vaizey (31) for *Polytrichum* notes "that it is apparently effected by the cells of the young calyptra becoming hard and thick-walled before it is separated from the vaginula." He goes on to explain that with further growth the apex of the young sporogonium is unable to push past the calyptra, and hence "the lower apex is forced down into the stem of the oophyte through the softer to the harder tissues, when the pressure on the calyptra becomes so great that it is torn away from the vaginula." Actually in *Cyathophorum* the apex and the whole upper part of the young sporogonium do not touch the calyptra at all (Fig. 49). The actual portion of the embryo which appears to force off the calyptra is the "swelling" which later gives rise to the capsule, and especially the peculiar "collar" of tissue already referred to. However, neither the "swelling" nor the "collar" develop until the embryo is some size, yet in spite of this fact its lower extremity has already penetrated practically as far as it ever does. Although this is partially explained by the secondary growth of the venter, it seems that some process of digestion by the young embryo is responsible for the appearance usually attributed to the "growing down" of the seta at a later stage.

SUMMARY.

1. A developmental series of the antheridium and archegonium of *Cyathophorum bulbosum* is given.

2. The sequence of divisions in the developing young sporogonium is studied.

3. The formation of the capsule, with the origin of the fertile tissue and air space is described, and also an account given of the mature sporogonium.

4. The ripening of the spores, their germination, and the growth of the protonema is described.

5. A general account of the gametophyte of *Cyathophorum* is outlined, with a short note on its occurrence and ecology.

6. Points of difference between this genus and others are discussed.

7. Various methods of killing and fixing, infiltration, etc., are given, and their results commented upon.

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Remarks on \times *Leucoraoulia*.

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[Read before Wellington Philosophical Society, August 24, 1938; received by the Editor, September 14, 1938; issued separately, March, 1939.]

INTRODUCTORY.

THE delimitation of genera in the gnaphalioid composites is notoriously difficult, and New Zealand species have not escaped shuffling and reshuffling. It is now recognized that hybridism plays a part in the complex linkages. In an earlier paper (Allan, 1935, p. 224) remarks were offered on the leaf-characters of the "vegetable sheep" group of *Raoulia*. The polymorphy of *R. eximia* was pointed out, and the possibility that hybrids occurred between *R. bryoides*, *R. eximia*, and *R. mammillaris*. It was shown that *R. bryoides* belongs to the section "uninerves." Here, I discuss hybrids noted between *Leucogenes* and *Raoulia* (subg. *Psychrophyton*), mainly observed during a survey made under grant from the Royal Society of London. For opportunities to study herbarium material, I am greatly indebted to Miss L. M. Cranwell (Auckland Memorial Museum), Miss E. M. Heine (Dominion Museum), Rev. Dr J. E. Holloway (Buchanan Herbarium), the Director, Royal Botanic Gardens, Kew (Kew Herbarium), the Keeper in Botany, British Museum of Natural History, Professor A. Wall, and Messrs F. G. Gibbs, R. M. Laing, W. Martin, G. Simpson, and J. Scott Thomson. My colleague, Mr V. D. Zotov, has assisted greatly by useful criticism and by providing the illustrations here used.

Earlier, Cockayne (1928, p. 284) had written of *Raoulia rubra*: "Apparently, this crosses with *Leucogenes Leontopodium*, one of the hybrids being the so-called species *Raoulia Loganii* (Buch.) Cheesem. Elsewhere, similar hybrids occur between *Leucogenes grandiceps* and *Raoulia bryoides*, one of which—described from individual only—is *Helichrysum pauciflorum* T. Kirk. Probably, *Raoulia Gibbsii* Cheesem., *Leucogenes Grahami* Petrie, and a Stewart Island plant, originally referred by me to *R. Loganii* (in this case one parent would be *R. Goyeni*) are all edelweiss-vegetable sheep hybrids. H. H. Allan and I myself have found a number of other forms to which we attribute the same origin, and we have given to all such the provisional hybrid generic name \times *Leucoraoulia*." Cockayne and Allan (1934, p. 49) listed the groups: *L. grandiceps* \times *R. bryoides*; *L. grandiceps* \times *R. Goyeni*; *L. Leontopodium* \times *R. Grandiflora* (doubtfully), and *L. Leontopodium* \times *R. rubra*. They remarked, "*Helichrysum Grahami* Petrie is possibly *L. grandiceps* \times *H. selago*."

THE GENERA.

Raoulia was founded by Hooker (1853, p. 134) to include five species, and has been maintained by subsequent taxonomists. He remarks: "As a genus, it is not easily defined, except by its size and habit; it differs from *Ozothamnus* in the regular series of female florets; from *Helichrysum* by its habit, and very narrow receptacle; from *Gnaphalium* by the same characters." Later Hooker (1864,

p. 147) included twelve species, dividing them into two groups. "It contains two natural and most distinct sections, of which one . . . has a convex, often hispid receptacle; achenes with very long silky hairs, a thickened areole at their base; and stout, rigid opaque pappus-hairs thickened at the tip; these, probably, constitute a good genus, to which the name *Raoulia* may be retained; the others may, perhaps, fall into *Gnaphalium* or *Helichrysum*."

Beauverd (1910, p. 227) created the genus, *Psychrophyton* for the section with pappus hairs thickened above, and retained the residue in *Raoulia*. He is also (1910, p. 241) the creator of the genus *Leucogenes* to contain *Helichrysum* *Leontopodium* Hook. f. and *Gnaphalium grandiceps* Hook. f. Clear lines of differentiation between the three genera were drawn up. As between *Leucogenes* and *Psychrophyton* he remarks (1910, p. 218 and p. 242), "la principale différence entre ces deux genres porte 1° sur la nature de l'akène ♂, qui est fertile chez les *Leucogenes* et stérile (toujours?) chez le *Psychrophyton*; 2° l'anatomie foliaire, qui est du type dimorphe chez les *Leucogenes* et du type homomorphe chez le *Psychrophyton*," and "sauf en ce qui concerne la forme du stigmate et l'anatomie des feuilles florales, les affinités extérieures des *Leucogenes* sont avant tout pour le genre *Psychrophyton*." The stigma differences are given as: *Psychrophyton* "sommet triangulaire ou lanceolé," *Leucogenes* "sommet tronqué ou émarginé."

Later, Beauverd (1912, p. 41) reduced *Psychrophyton* to a subgenus of *Raoulia*, principally because *R. Petriensis* was found to be "précisément un type de transition d'autant plus indiscutable que du côté des *Psychrophyton* nouvellement examinés, nous avons observé chez certains organes (les stigmates tout spécialement) des formes exclusivement admises jusqu'alors dans la constante générique adverse." As Beauverd (1912, pp. 46, 48) states *R. Petriensis* has the numerous pappus hairs of *Eu-raoulia*, but these are in large part thickened upwards, while the achenes are pubescent. Even in species of *Eu-raoulia* clavately thickened hairs are occasional, and an examination of many specimens shows that *Psychrophyton* cannot be separated from *Eu-raoulia* as a clear-cut genus. *R. Petriensis* is a most distinct species; all the specimens I have seen agree in details, and there are no grounds for attributing its intermediate position to hybridism.

The two species of *Leucogenes* are, of course, easily recognised by the large, radiating floral leaves subtending the congested heads. The stigma differences are not so clear-cut, and the genus is, therefore, exceedingly close to those members of *Raoulia* coming into the subgenus *Psychrophyton* in the strict sense. The occurrence of hybrids is not, therefore, altogether surprising. As the bulk of the specimens seen by me are quite barren, I have illustrated leaf-characters.

HYBRID GROUPS.

1. *Leucogenes grandiceps* × *R. bryoides*. Figs. 1-3.

L. grandiceps occurs on the mountains of South Island throughout, and on Stewart Island. *R. bryoides* is confined to the drier

mountains of South Island. The two are found together in numerous localities. Forms of intermediate character are now known to be fairly frequent, but never occurring in quantity.

Kirk (1895, p. 351) based his *Helichrysum pauciflorum* (Fig. 2) on a specimen collected by L. Cockayne on the Craigieburn Mountains. He remarks on its "closest external appearance to *H. grandiceps*," differing in the "solitary head" and the "total absence of the conspicuous woolly bracts." Cheeseman (1925, p. 984) adds specimens of Cockayne from the Candlestick Mountains, and of Petrie from the Craigieburns. He notes that the "pappus hairs are those of the *Psychrophyton* section of *Raoulia*, with which it also agrees in the hispid achenes," but does not place it in *Raoulia* on account of the "very different habit."

Cheeseman (1910, p. 216) published his *Raoulia Gibbsii* on specimens collected by Gibbs on Mount Starveall (Fig. 3) and Slaty Peak. He notes its very close resemblance to *R. bryoides*, but emphasizes its larger leaves and heads, and comparatively lax habit. The heads, as in *H. pauciflorum*, are sunk among the uppermost leaves, and contain more numerous florets than those of *R. bryoides*. He notes the observation of Mr. Gibbs that "at a little distance, it can easily be mistaken for a barren specimen of *Helichrysum grandiceps*." There is very little, indeed, to separate the type specimens of *H. pauciflorum* and the Mount Starveall and other specimens. It will be seen that the leaves may be "uninerved" as in *R. bryoides*, or "trinerved" as in *L. grandiceps*.

All the specimens here placed as hybrids are very similar in leaf-characters, though some may be dense cushions (as in the Mount Misery specimens) others (as in the Mount Starveall specimens) more open in habit. The conclusion that these aberrant plants are hybrids is strengthened by their sporadic occurrence and generally barren nature. Further material has been gathered on Mt. Fishtail (J. W. Hadfield), Mt. Schiza (J. W. Hadfield), Mt. Torlesse and the Craigieburn Mountains (H. H. A.) and Mt. Misery (H. H. A.). Similar forms have been collected on Mount Hutt (H. H. A.), where *R. mammillaris* rather than *R. bryoides* may be one parent. Mr. Gibbs has suggested to me that certain of his Mt. Starveall and Slaty Peak specimens may well be *R. bryoides* \times *grandiflora*.

2. *Leucogenes Leontopodium* \times *Raoulia rubra*. Figs. 4-8.

L. Leontopodium has a wide range in North and South Islands, and meets *R. rubra* on the Tararua Mountains. Buchanan (1882, p. 350) based his *Haastia Loganii* on specimens from Mt. Holdsworth. He describes the heads as 40-50 flowered, and the florets as "red-dish." His illustration shows a three-nerved leaf. Kirk (1899, p. 310) had only barren specimens, but pointed out that Buchanan's description and illustration of the achene, "compressed, linear, and covered with long, silky hairs," fitted *Helichrysum* or *Raoulia*. Cheeseman (1925, p. 972), who had seen a number of specimens from the Tararua Mountains, gives the florets as 20-40, and remarks: "the pappus hairs are precisely those of the section *Psychrophyton* of

Raoulia, in which genus it must be placed." I have seen a number of other specimens from the Tararua Mountains, but all in a barren state. All agree fairly well with one another, but some (Fig. 8) are much wider-leaved than others, and the leaves are occasionally uninerved. The intermediate nature of the leaves, the sporadic occurrences, and the general barrenness, all confirm the hybrid origin suggested. The reddish flowers also indicate the *R. rubra* parentage.

3. *Leucogenes grandiceps* × *Raoulia Goyeni*. Fig. 9.

Cockayne (1909, p. 64) doubtfully identified a specimen he collected on rocky ground near the summit of Mount Anglem, Stewart Island, as *Helichrysum Loganii*. Cheeseman (1925, p. 972) included it under *R. Loganii*, without any expression of doubt. No further specimens have been collected. Kirk (1884, p. 373) describes the leaves of *R. Goyeni* (confined to Stewart Island) as having "purple margins" and "close set whitish hairs." In his fuller description (1899, p. 306) he does not refer to the purple colouration, and refers to the hairs as "short, white, uneven." Beauverd (1912, p. 49) states "cils blanc-verdatre." Cheeseman (1928, p. 971) gives the hair colour as "white." In all the specimens seen by me (herbarium material only) the purple colouration is often quite marked, and the hairs of the summit leaves, seen in mass, are a dark brown. Seen individually, the hairs are paler to whitish. The specimens of the alleged *R. Loganii* are more open in habit than those of *R. Goyeni*, with looser hairs. These are tawny in mass, of a lighter shade than those of *R. Goyeni*, and the leaf margins occasionally show traces of purple. Leaves of both uninerved and trinerved type are to be found.

4. *Leucogenes Leontopodium* × *Raoulia grandiflora*. Figs. 10-12.

R. grandiflora extends all through and beyond the area occupied by *L. Leontopodium*.

Buchanan (1877, p. 529) based his *Gnaphalium* (*Helichrysum*) *fasciculatum* on specimens collected by Travers in the Tararua Mountains, and noted its similarity to *R. grandiflora*, except that it is "larger in all parts," and has the flower-heads in "a sessile closely compacted fascicle." Cheeseman (1912, p. 24) pointed out that the pappus-hairs are of the *Psychrophyton-Leucogenes* type. He reduces it to a variety of *R. grandiflora*. The figures (10-12) show the intermediate character of the leaves, and the congested flower-heads also indicate a *L. Leontopodium* parentage. No further flowering material has been noted, but specimens showing closely similar leaves and habit have been collected in several localities, growing in company with the parents. Certain of the specimens collected by Mr. Gibbs of Mount Patriarch (Fig. 12) and Slaty Peak, attributed to *R. Gibbsii*, belong here.

5. *Helichrysum* (*Leucogenes*) *Grahami* Petrie. Fig. 13.

This was described by Petrie (1913, p. 268) from a single collection made by Graham on the Sebastopol Ridge, Sealey Range. He speaks of the leaves as "everywhere densely clothed with loose greyish-white cottony tomentum, a few of the uppermost longer and broader, but not exceeding the heads." These are "in capitate

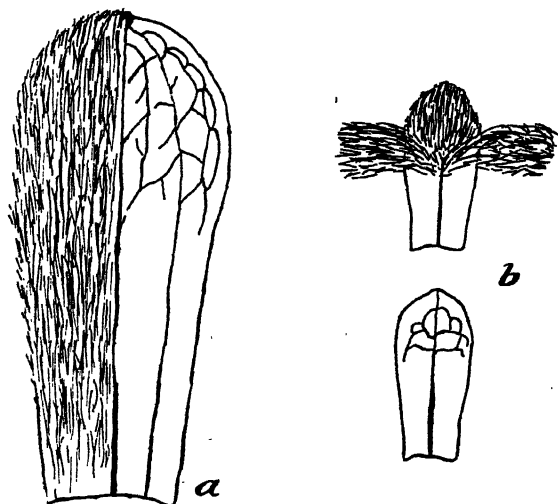


FIG. 1. *Leucogenes grandiceps*, a; *Raoulia bryoides*, b.

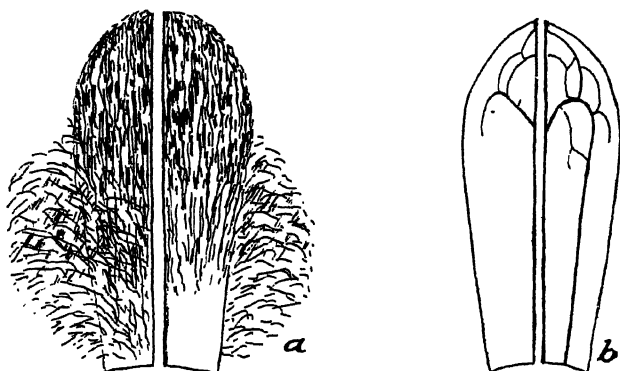


FIG. 2. *Helichrysum pauciflorum*; type specimen. Lower and upper surfaces, a; uni- and trinerved forms, b.

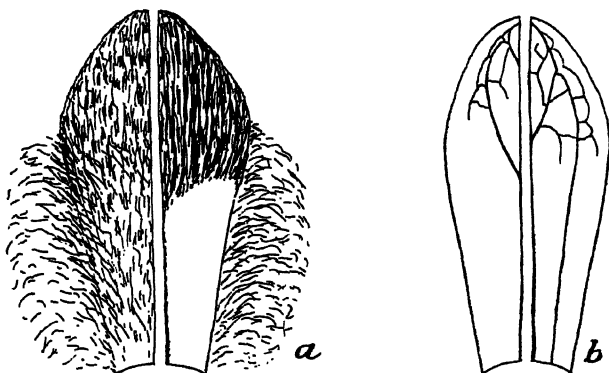


FIG. 3. *Raoulia Gibbsii*; Mount Starveall. Lower and upper surfaces, a; uni- and trinerved forms, b.

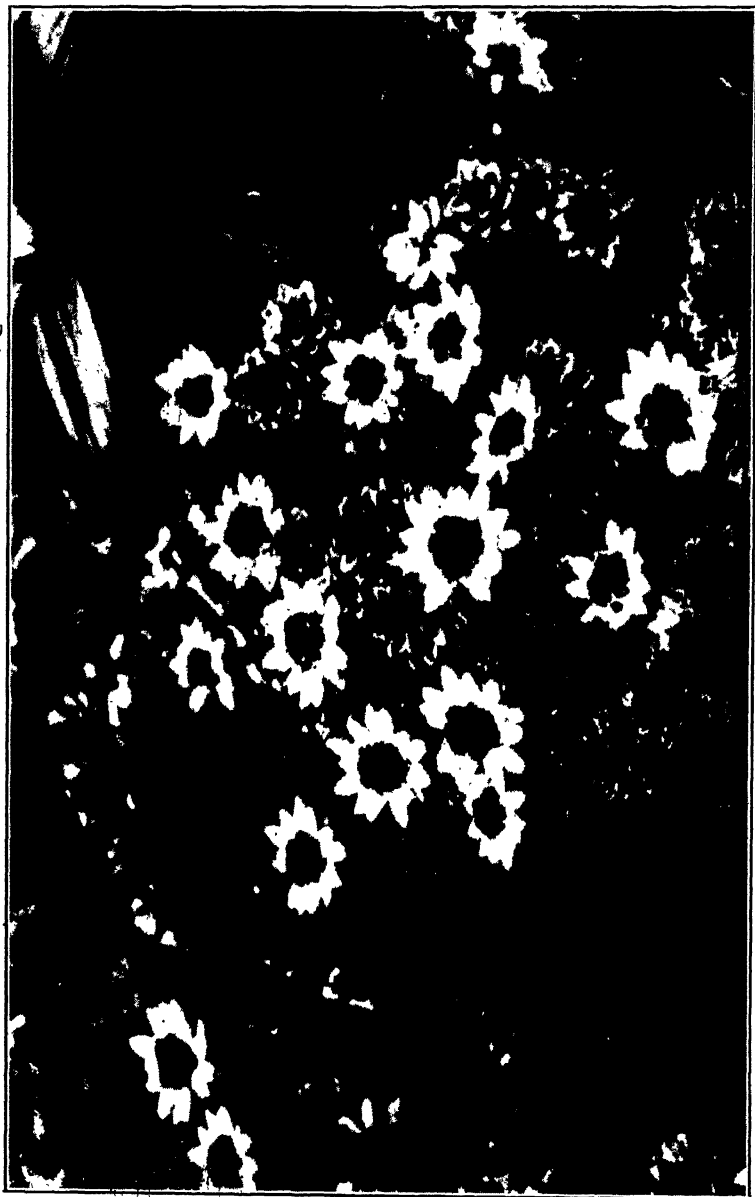


FIG. 4. *Leucogenes Leontopodium*, Tararua Mountains, Photo., V. D. Zotov.

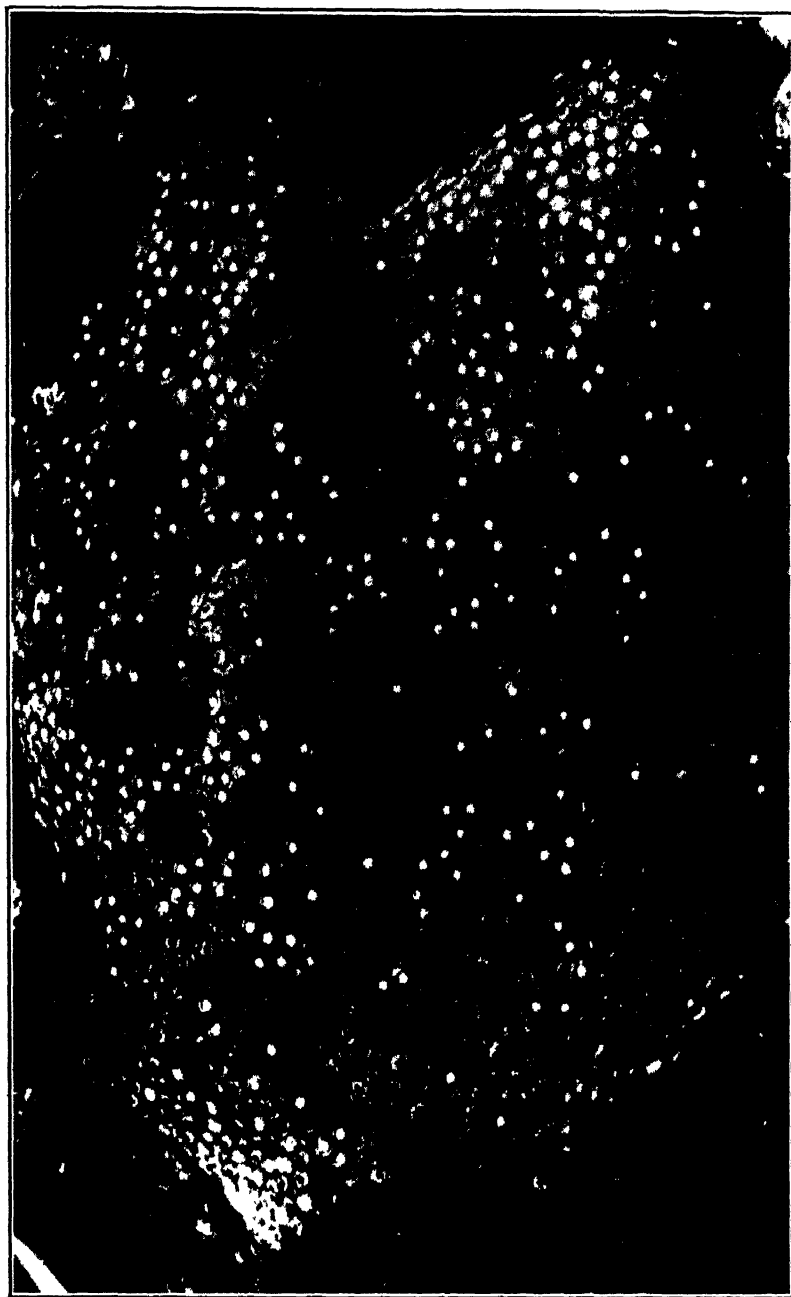


FIG. 5. *Raoulia rubra*, Taranui Mountains. Photo., V. D. Zotov.



Fig. 6. *Raoulia Loganii*, Tararua Mountains. Photo., V. D. Zotov.

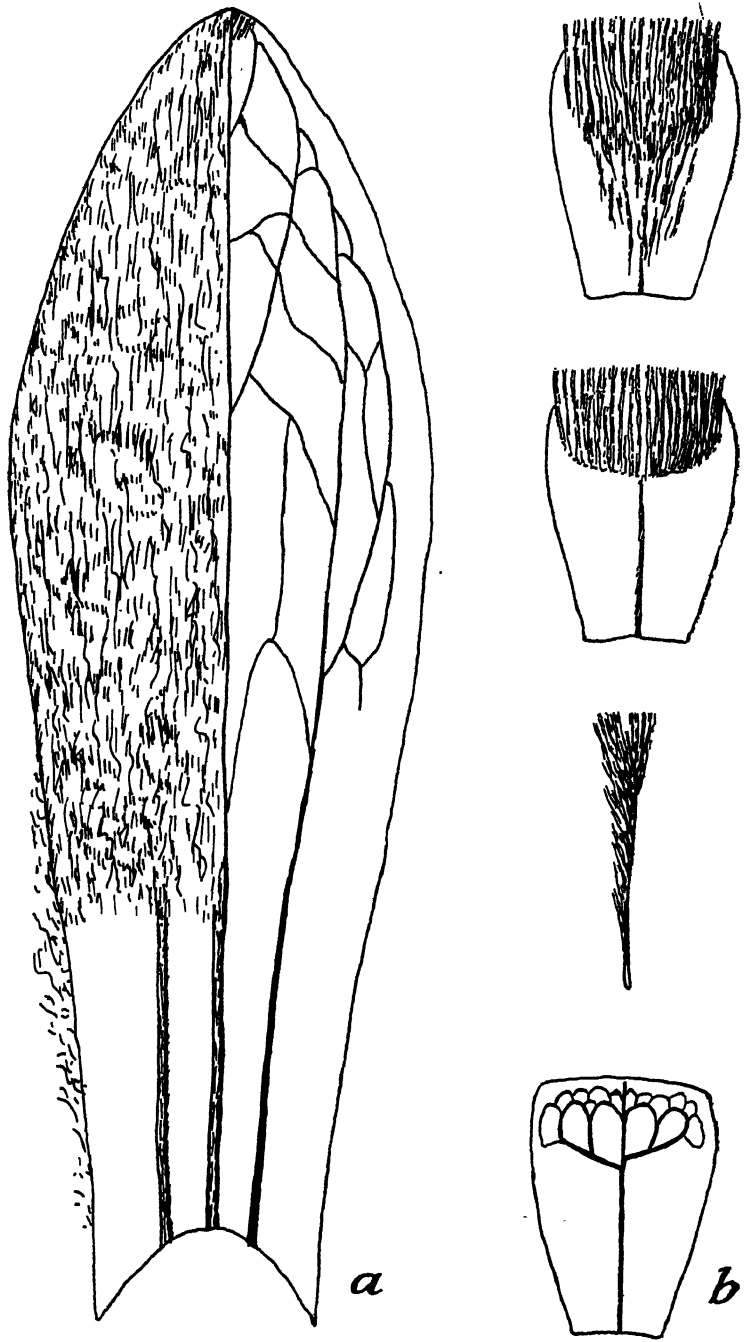


FIG. 7. *Leucogenes Leontopodium*, a; *Raoulia rubra*, b.

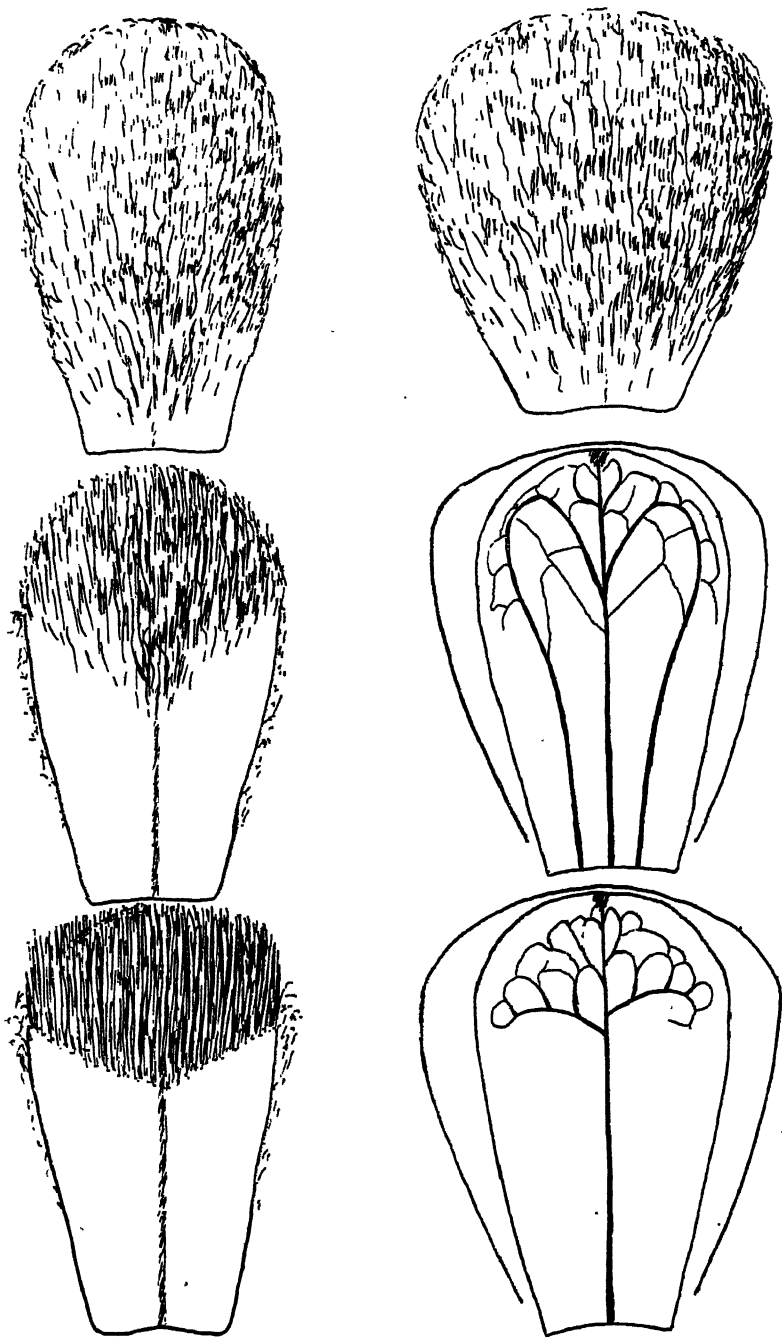


FIG. 8. *Raoulia Loganii*, Mount Holdsworth, showing narrower and broader leaved forms, uni- and trinerved in both.

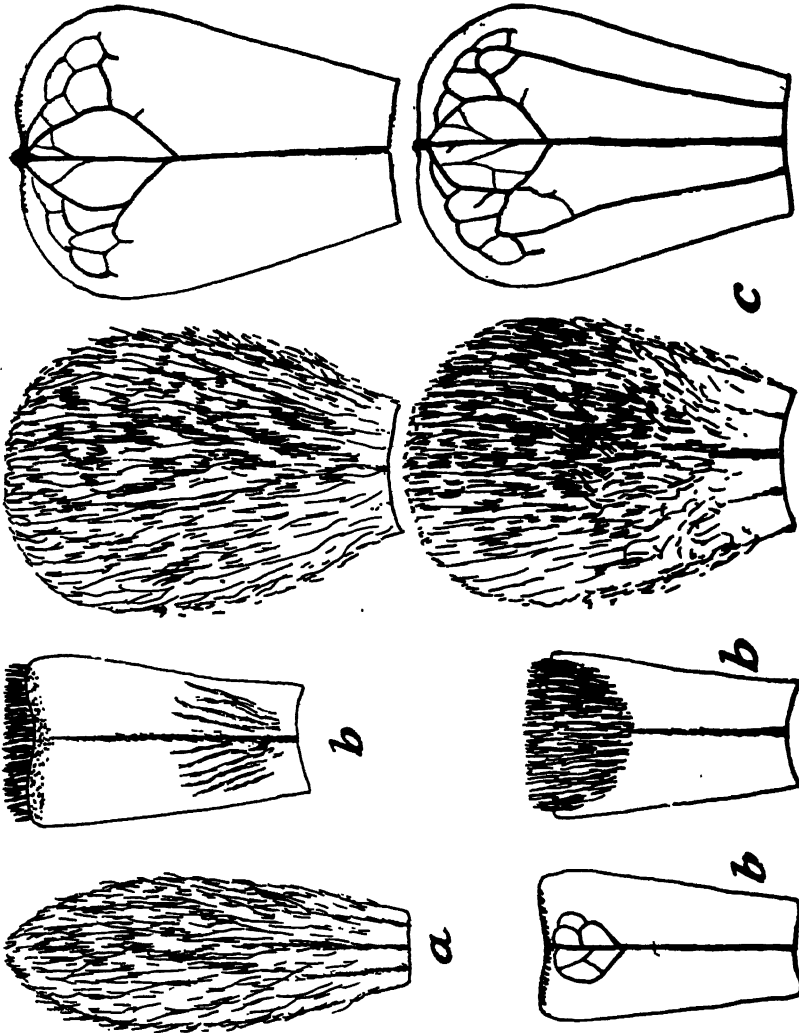


FIG. 9. *Leucogenes grandiceps*, a (small leaf); *Raoulia Goyeni*, b; Hybrid from Mount Anglem, c.

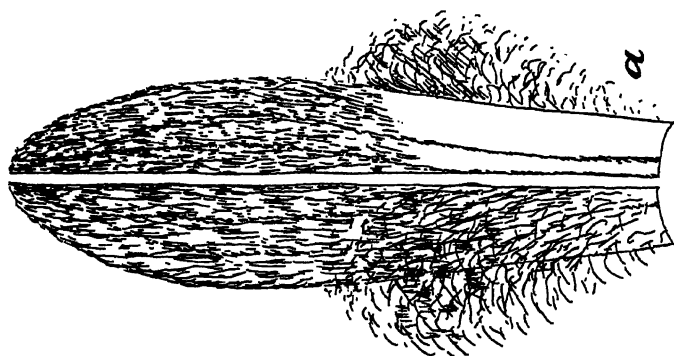
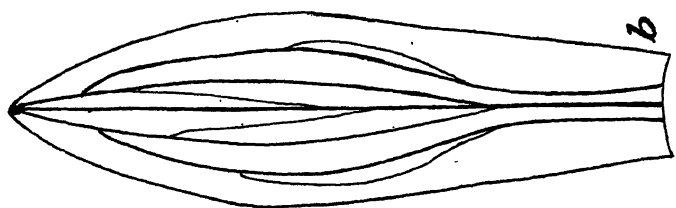


FIG. 11. *Helichrysum fasciculatum*, type specimen. Lower and upper surfaces, a; venation, b.

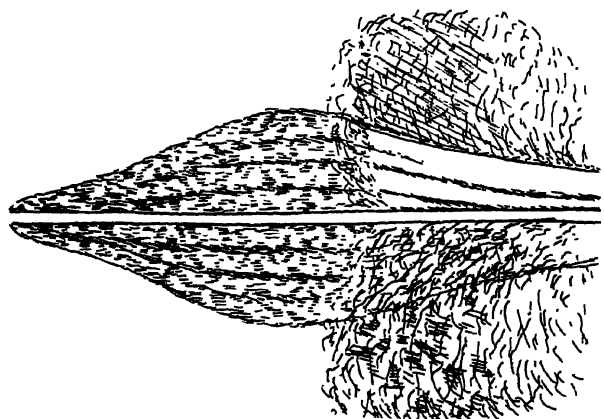
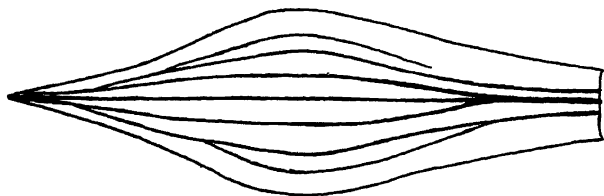


FIG. 10. *Raoulia grandiflora*.

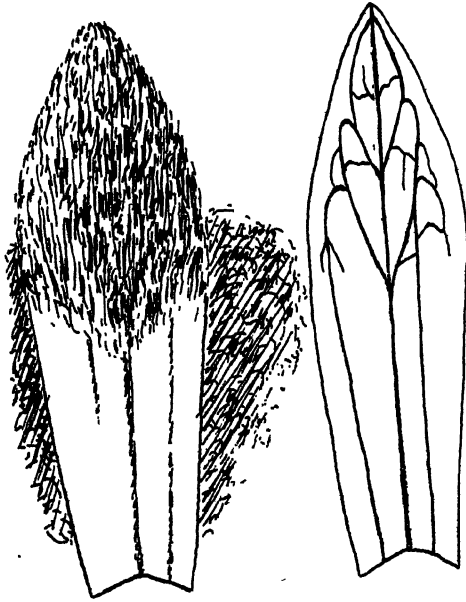


FIG. 12. *Raculia Gibbsii*, Mount Patriarch.

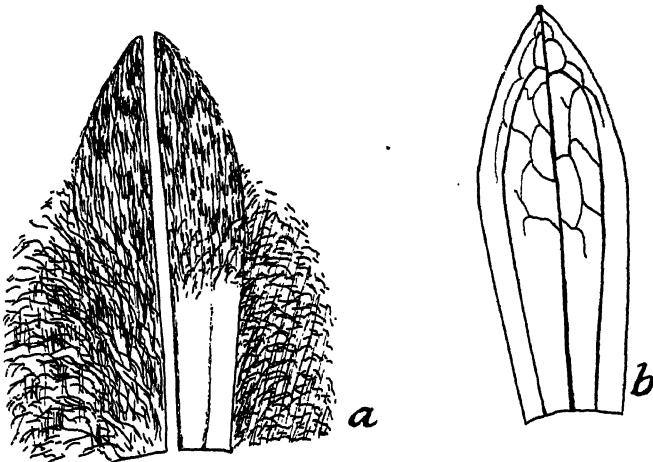


FIG. 13. *Leucogenes Grahamei*, type specimen. Lower and upper surfaces, a; venation, b.

fascicles." In some respects it is intermediate between *Helichrysum* Vaill. and *Leucogenes* Beauverd. Cheeseman (1925, p. 980) places it doubtfully in *Leucogenes*, but remarks, "But the inflorescence, pappus-hairs, and achenes are so different from those of *Leucogenes* that I anticipate that it will ultimately fall into a different genus." The resemblance of the leaves (Fig. 13) to those of the cross *L. Leontopodium* \times *R. grandiflora* will be noted. Cockayne and Allan (1934, p. 49) suggested as a possible origin *L. grandiceps* \times *Helichrysum* *Selago*. Certainly *L. grandiceps* appears very likely to be one parent, but until further search is made the matter must rest in doubt. I have collected a rather similar, quite sterile, plant on Mount Hutt, in company with *L. grandiceps*, *H. Selago* and *R. mammillaris*.

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Maccoyella and Aucellina in the Taitai Series.

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[Read before the Geological Section, Wellington Philosophical Society, June 14, 1938; received by the Editor, September 1, 1938; issued separately, March, 1939.]

UNTIL the present record, the genus *Maccoyella* has been known only from Australia, where it occurs rather widely in the Roma Series. From its ammonite fauna F. W. Whitehouse (1926) showed that this Series is of Aptian age. The *Maccoyellas* occur in the upper three of the four zones of the Aptian, being "of particular value in zoning the Roma Series." (Whitehouse, 1929, p. 277.)

The earliest known forms have primary and secondary ribs only, later ones develop tertiary ribs, and the most advanced have quaternary ribs.

The single specimen of the new species *Maccoyella magnata*, a left valve, is not well preserved, nor is it complete. Nevertheless, sufficient remains to put the generic position beyond doubt and to allow enough details for specific recognition.

A species of *Aucellina* is also commented on below, because it occurs in the same beds (Taitai Series) as does *Maccoyella*.

The specimens were collected by Mr. M. Ongley during his geological survey of the Wairoa Sub-division.

Family PTERIIDAE (= AVICULIDAE).

Genus MACCOYELLA Etheridge.

1892. *Geol. and Pal. Queensl. and New Guinea*, p. 451.

Genotype (original designation): *Avicula barklyi* Moore, Aptian, Australia.

Figured: Moore, *Quart. Journ. Geol. Soc.*, vol. 26, p. 245, pl. 11, figs. 1, 2.

Maccoyella magnata n.sp. Plate 61, figs. 1, 2.

Left valve large, moderately inflated, thick towards the beaks, inequilateral; outline subcircular, posterior wing apparently not produced nor defined. Umbo overhanging the area. Anterior margin descending steeply, having a wide byssal sinus, the upper margin of which is slightly reflected (forming scobinate lamellae). Owing to erosion of the surface, the number of radial ribs is uncertain, but there are probably about 22 subequal ribs with weaker ones in the wide flat interspaces. On analogy with the Australian species, these would be ranked as about 11 primary ribs, and 11 secondaries of approximately equal strength, each interspace containing a small tertiary rib about half as strong. A feeble quaternary rib is to be seen on some of the interspaces. Hinge having a broad, finely striate, ligamental area extending from the top of the scobinate lamellae backwards across the top of the cardinal socket to an obliquely triangular, slightly concave resilifer. Cardinal socket sharply raised along a definite line posteriorly, and having, anteroventrally, a thick, high, rounded margin.

Holotype (unique) in New Zealand Geological Survey collection.

Length, 122 mm. (estimated); height, 120 mm.; inflation, 25 mm.

Locality: Geol. Surv. 1989. Moanui Survey District, on track 50 chains north of Koranga River, and 5 miles 10 chains at 315° from Maungatapere Trig.

Age: Taitai Series (probably Upper Aptian).

This species appears to be the largest yet described. The posterior dorsal margin has been broken off, but sufficient of the posterior margin remains to show its position fairly closely.

The radials tend to be weakly moniliform and the interspaces weakly concentrically ridged. This, however, is a development of weathering on the peculiar "lenticular" internal structure of the shell remarked on by Etheridge (1902), and showing plainly over much of the surface.

Maccoyella magnata has sculpture at almost the same stage as that of *M. reflecta* (Moore) as figured by Etheridge (1902, pl. 2, fig. 1). It differs widely from this species, however, in shape, having no flat posterior wing and a considerably smaller apical angle, viz., about 120° instead of 180°. It thus approximates *M. barklyi* in outline, but its sculpture is much more advanced.

The stratigraphic significance of *Maccoyella* in New Zealand is discussed below.

Genus AUCELLINA Pompeckj.

1901. *Neu. Jahrb. f. Min. Geol. u. Pal.*, vol. 14, p. 365.

Genotype: *Avicula gryphaeoides* Sowerby, Albian-Cenomanian.

Figured: 1901. Pompeckj, *op. cit.*, plate 16, figs. 6-8.

1905. Woods, *Cret. Lam.*, vol. 2, pt. 2, pl. 10, figs. 6-13.

Pompeckj named two species, *A. aptiensis* d'Orb. and *A. gryphaeoides* Sowby. as types for his genus, and as far as the writer is aware, no one has yet, in accordance with modern procedure, designated a definite genotype. Since it seems desirable that this should be done, the older species *A. gryphaeoides* Sowby. is here chosen.

Aucellina sp.

Localities: G.S. 1403. Ridge at head of Elmar and Harding Streams, Motu Surv. Dist., north-west corner.

G.S. 1989. Track, Moanui Survey District, 50 chains north of Koranga River and 5 miles 10 chains at 315° from Maungatapere Trig.

G.S. 2084. Ridge leading up west from head of Harding Stream, Motu Surv. Dist., south-west corner.

Age: Taitai Series (probably Upper Aptian).

The writer (Marwick, 1929, p. 5) previously identified these fossils as the Jurassic *Buchia* (= *Aucella*) *spitiensis* (Holdhaus). Since then Pompeckj's paper has become available, and in the light of this and of the association with *Maccoyella*, the specimens seem undoubtedly to be *Aucellina*. Owing to poor preservation, however, the critical hinge and ear details have not yet been made out.

The New Zealand shells have a greatly inflated, oblique left valve with high, strongly incurved beaks. The right valve is almost flat and subcircular, with a short hinge line. The right byssal ear is not fully preserved except as casts which indicate a relatively large, thick, spoon-shaped ear with ridges on the lower side. It appears to have been set obliquely, so that the byssal notch is also oblique and not wide open like typical *Aucellina*. However, this may be due to distortion.

Of the two European species, *A. aptiensis* d'Orb. and *A. gryphaeoides* Sowby., described in detail and beautifully figured by Pompeckj, the New Zealand specimens agree closer with *gryphaeoides*. They are, however, on the average, more oblique, and the beaks are considerably higher and more strongly incurved. The left valve of *A. hughendenensis* Etheridge, Queensland, figured by that author (1907, pl. 61, fig. 8) as a typical specimen is very like some of the New Zealand specimens, and Pompeckj considered *hughendenensis* "closely related to, perhaps even in part identical with" *gryphaeoides*. Consequently it seems probable that the New Zealand shells belong also to the *gryphaeoides* stock; but whether they are to be considered as specifically identical or whether they should be recognised as distinct can be decided when more material is available.

Age of the Taitai Series.

In Australia, according to Whitehouse (1929), *Maccoyella* is limited to the Roma Series which is Aptian, and *Aucellina* to the Tambo Series which is Upper Albian. In Europe, on the other hand, *Aucellina* occurs as early as the Upper Aptian, so that the association of *Aucellina* with *Maccoyella* in the Taitai Series is not surprising. Moreover, the presence of quaternary ribs on *Maccoyella magnata* agrees with the *Aucellina* in indicating a late Aptian horizon. Consequently the age of the Taitai Series can reasonably be regarded as Upper Aptian, that is, Gargasian.

Stratigraphic Significance.

Considerable interest attaches to the Taitai Series because of the possibility that over a wide area it has been overthrust for many miles to rest upon rocks of the Tapuwaeroa and Raukumara series. (M. Ongley, 1930, p. 376). The present writer's mistake in identifying the *Aucellina* as *Aucella* cf. *spitiensis* seemed to give strong palaeontologic support to the overthrust hypothesis. The present evidence does not altogether withdraw this support, but modifies it, in that the time interval between the Taitai and the Raukumara Series is greatly reduced.

No reliable age has yet been assigned to the Tapuwaeroa Series except that this seems undoubtedly younger than the Raukumara Series. The only significant fossil so far discovered in the Raukumara beds is *Inoceramus* (*Callistoceramus*) *bicorrugatus* Marw. which occurs also in Marlborough, rather above the middle of the Clarentian (Nidd mudstone). The associated beds were, on the evidence of the ammonites, correlated by H. Woods (1917, p. 2) with the Lower Utatur of India, equivalent to the Upper Gault and Upper Greensand.

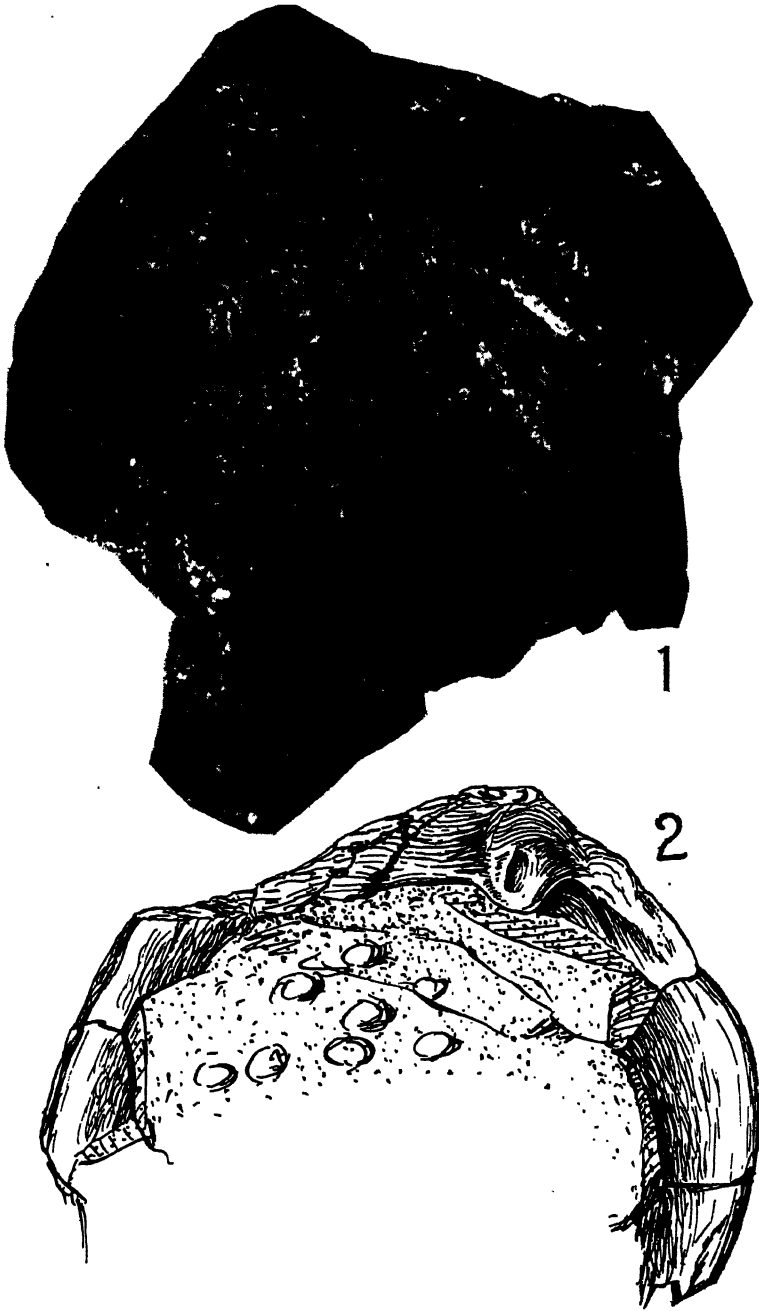


FIG. 1.—*Maccoyella magnata* n.sp. Holotype, a left valve.

FIG. 2.—Same showing hinge.

(Both slightly reduced.)

According to this, *Inoceramus bicorrugatus* should be Upper Albian or Cenomanian. R. Heinz (1928, p. 123), indeed, on the occurrence of the species in Germany, favoured a higher horizon, namely upper Upper Turonian. No evidence suggests that the Raukumara Series is as old as Aptian. Therefore, if the Taitai Series is really, as the *Maccoyella* indicates, Upper Aptian, then it seems certainly to have been overthrust to its present position.

The alternative, already suggested, is that we must extend the time range of one or both of the fossils concerned. The hypothesis of forms lingering on in one country has often been invoked to solve stratigraphic difficulties that were really the result of incorrect data. Nevertheless, it is a commonplace that some animal groups (also plants) have survived in one region long after they have died out in another. This is particularly true as applied to the larger zoological divisions; but, so far as the finer divisions, such as species, are concerned, the principle has a limited application in time because of the evolutionary changes that constantly went on.

From this viewpoint, the problem to be decided is whether:—

1. To take *Inoceramus bicorrugatus* at its face value and extend the range of *Maccoyella* in New Zealand to the Cenomanian or even (according to Heinz) into the Turonian.
2. To consider *Maccoyella magnata* as agreeing in age with its Australian relatives and to push the range of *I. bicorrugatus* back to Lower Aptian.
3. To extend the range of *Maccoyella* into the Upper Albian and that of *I. bicorrugatus* back to the Lower Albian.

Each of these solutions has its objections, and in view of the fact that only one battered and broken specimen of *Maccoyella* is known from New Zealand, it is perhaps rash to express an opinion on the matter.

It can, nevertheless, be said that the palaeontological evidence so far as it goes supports the hypothesis of overthrust.

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The Molluscan Faunule at Pakaurangi Point, Kaipara —No. 1.

By C. R. LAWS, D.Sc., Auckland.

[Read before the Auckland Institute, October 4, 1938; received by the Editor,
October 10, 1938; issued separately, March, 1939.]

RECENT collecting from the Tertiary beds at Pakaurangi Point, Kaipara Harbour, has made it possible to add a large number of new records of minute molluscs to the faunule, as well as new records of a number of larger species. There are 87 molluscs whose record is new to the beds. About 70 new species are named in the paper, and it has been found necessary to alter the identification of 21 fossils in Marshall's list (*Trans. N.Z. Inst.*, vol. 50, p. 273, 1918).

Not all the forms recently obtained are dealt with at present, as further investigation of the faunule is being undertaken and other papers are anticipated.

The writer is greatly indebted to Professor J. A. Bartrum, of Auckland University College, for his very willing assistance in photographing the new species; also to Mr J. Grant, honorary conchologist at the Wanganui Museum, and to Mr R. A. Falla, of Canterbury Museum, for their readiness in permitting the writer to inspect type-material. To Dr J. Marwick, Dr H. J. Finlay, and Mr A. W. B. Powell he is also grateful for assistance in identifying certain of the minute shells.

The holotypes of species described in this paper are located in the writer's collection.

LIST OF SPECIES DESCRIBED OR RECORDED IN THIS PAPER.

NR indicates that the record is a new one for the locality.

Present Classification.	Marshall's Identification, 1918.	
PELECYPODA.		
<i>Nucula otamatea</i> n.sp.		NR
<i>Nuculana</i> (<i>Saccella</i>) <i>uplicarina</i> n.sp.	<i>Leda semiteres</i> Hutton	
<i>Nuculana</i> (<i>Jupiteria</i>) <i>parleachi</i> n.sp.		NR
<i>Nuculana</i> (<i>Jupiteria</i>) <i>vadosa</i> n.sp.		NR
<i>Nuculana</i> sp.		NR
<i>Ledella cliffdenensis</i> Powell		NR
" <i>Arca</i> " <i>mundeformata</i> n.sp.	<i>Arca novae-zelandiae</i> Smith (?)	
<i>Glycymeris</i> (<i>Grandaxinea</i>) <i>finlayi</i> n.sp.	<i>Glycymeris subglobus</i> Suter	
<i>Limopsis propeinvalida</i> n.sp.		NR
<i>Hochstetteria</i> n.sp.		NR
<i>Cratis ovata</i> Marwick.		NR
<i>Chlamys</i> sp.		? NR
<i>Cyclopecten</i> (<i>Cyclochlams</i>) <i>shepherdi</i> n.sp.		
<i>Otenamussium vafer</i> Marwick		NR
<i>Mantellum</i> sp.		NR
<i>Kidderia otamatea</i> n.sp.		NR
<i>Salasputium tinopaica</i> n.sp.		NR
<i>Dinys</i> n.sp.		NR

Present Classification.	Marshall's Identification, 1918.	
<i>Cardita kaiparaensis</i> n.sp.	<i>Cardita calyculata</i> Linn.	NR
<i>Eulopia</i> (<i>Notomyrtea</i>) n.sp.		NR
<i>Gonimyritea</i> sp.		NR
<i>Notolepton sanguineum</i> (Hutton)		
<i>Rochefortula</i> cf. <i>kaawaensis</i> Bart. and Pow.		NR
<i>Tellinella ferrari</i> Marwick	<i>Tellina eugonia</i> Suter	
<i>Angulus</i> (<i>Peronidia</i>) <i>inflata</i> n.sp.	<i>Tellina glabrella</i> Desh.	
<i>Nemocardium</i> (<i>Pratulium</i>) n.sp.	<i>Cardium pulchellum</i> Gray	
<i>Hiatella</i> cf. <i>australis</i> (Lam.)		NR
GASTEROPODA.		
<i>Scissurella condita</i> n.sp.		NR
<i>Schizotrochus miocenica</i> n.sp.		NR
<i>Emarginula komitica</i> n.sp.		NR
<i>Emarginula kaiparica</i> n.sp.	<i>Emarginula striatula</i> Q. and G.	
<i>Maurea</i> sp.		NR
<i>Zetela hutchinsoniana</i> n.sp.		NR
<i>Zetela parvumbilicata</i> n.sp.		NR
<i>Antisolarium tricarinatum</i> n.sp.		NR
<i>Conominolium</i> n.sp.	<i>? Solariella stoliczkai</i> Zitt.	
<i>Lodderia komitica</i> n.sp.		NR
<i>Lodderia kaiparaensis</i> n.sp.		NR
<i>Elachorbis</i> n.sp.		NR
<i>Lissotesta alpha</i> n.sp.		NR
<i>Lissotesta beta</i> n.sp.		NR
<i>Lissotesta</i> n.sp.		NR
<i>Dolicrossea olifdenensis</i> Finlay	<i>Orossea labiata</i> Suter	
<i>Dolicrossea atypica</i> n.sp.		NR
<i>Crosseola sinemacula</i> n.sp.		NR
<i>Crosseola tenuisculpta</i> Laws		NR
<i>Orbitestella praetoreuma</i> n.sp.		NR
<i>Orbitestella praezinemoea</i> n.sp.		NR
<i>Zeradina aculeata</i> n.sp.		NR
<i>Zeradina</i> n.sp.		NR
<i>Zeradina</i> (<i>Radinista</i>) <i>viviennae</i> n.sp.		NR
<i>Zeradina</i> (<i>Naridista</i>) <i>jocelynae</i> n.subg., n.sp.		NR
<i>Haurakia onerata</i> n.sp.		NR
<i>Haurakia sodalis</i> n.sp.		NR
<i>Merelina saginata</i> n.sp.		NR
<i>Nobokira inflata</i> n.sp.		NR
<i>Dardanula praecursor</i> n.sp.		NR
<i>Brookesena duplicincta</i> n.sp.		NR
<i>Nozeba perpava</i> n.sp.		NR
<i>Socienna</i> n.sp.		NR
<i>Zaclys</i> (<i>Miopila</i>) <i>muero</i> n.sp.		NR
<i>Zaclys</i> (<i>Miopila</i>) <i>simulator</i> n.sp.	<i>Cerithiella fidioula</i> Suter	
<i>Ataxocerithium</i> sp.		NR
<i>Notosinister zespina</i> n.sp.		NR
<i>Notosinister</i> n.sp.		NR
<i>Notosinister</i> sp.		NR
<i>Triphora neozelanica</i> n.sp.		NR
<i>Maoricolpus</i> sp.	<i>Turritella semiconoava</i> Suter	
<i>Pareora striolata</i> (Hutton)		NR
<i>Mathilda</i> n.sp.		NR
<i>Ellatrinia kaiparaensis</i> n.sp.	<i>Trivia avellanoides</i> McCoy	
<i>Cypræerato</i> cf. <i>submorosa</i> Laws		NR
<i>Archierato zepyrolata</i> n.sp.		NR
<i>Archierato simulacrum</i> n.sp.		NR
<i>Charonia</i> cf. <i>olifdenensis</i> Finlay		NR
<i>Austrosassia zealta</i> n.sp.	<i>Cymatium minimum</i> Hutton	
<i>Oniscidia</i> cf. <i>finlayi</i> Laws		NR
<i>Cirsotrema firmatum</i> n.sp.	(?) <i>Epitonium browni</i> Zittel	

<i>Turriscula kaiparaensis</i> n.sp.		NR
<i>Pliciscula</i> n.sp.		NR
<i>Turbonilla komitica</i> Laws		
<i>Chemnitzia</i> sp.		NR
<i>Pyrgolampros pakaurangiensis</i> n.sp.		NR
<i>Finlayella angulifera</i> Laws		NR
<i>Eulimella komitica</i> n.sp.		NR
<i>Eulimella parlimbata</i> n.sp.		NR
<i>Eulimella imitator</i> n.sp.		NR
<i>Graphis neozelanica</i> n.sp.		NR
<i>Odostomia</i> n.sp.		NR
<i>Balcis badenia</i> n.sp.		NR
<i>Balcis waikomitica</i> n.sp.		NR
<i>Balcis kaiparaensis</i> n.sp.		NR
<i>Uromitra neozelanica</i> n.sp.		NR
<i>Verconella parans</i> Finlay		
<i>Hima (Mirua) separabilis</i> n.sp.	<i>Siphonalia dilatata</i> Q. and G.	
<i>Terefundus</i> n.sp.	<i>Alectrion socialis</i> Hutton	
<i>Merica kaiparaensis</i> n.sp.		NR
<i>Bathytoma bartrumi</i> n.sp.		NR
<i>Comitas kaipara</i> n.sp.	<i>Bathytoma haasti</i> Hutton	
<i>Inquisitor komitica</i> n.sp.	<i>Surcula fusiformis</i> Hutton	
<i>Daphnella kaiparica</i> n.sp.	<i>Drillia arcamoensis</i> Hutton	
<i>Clavus kaipara</i> n.sp.		NR
<i>Nepotilla bartrumi</i> n.sp.		NR
<i>Acteon procratericulatus</i> n.sp.	<i>Acteon craticulatus</i> Murd. and Sut.	NR
<i>Leucotina granulocostata</i> n.sp.		NR
<i>Ringicula zecorpulenta</i> n.sp.		NR
<i>Scaphander komitica</i> n.sp.		NR
<i>Cylichnania plana</i> n.sp.		NR
<i>Kaitoa recta</i> n.sp.		NR
<i>Atya lacrimula</i> n.sp.		NR
<i>Cadulus zecaninus</i> n.sp.	<i>Cadulus delicatulus</i> Suter	NR

PELECYPODA.

Nucula otamatea n.sp. (Fig. 3).

Shell small, outline very like that of *N. hartvigiana*, pouting posteriorly, keeled on antero-dorsal slope; beaks approximate, very near posterior. Posterior end descending at first obliquely and then curving downwards and descending vertically. Junction of antero-dorsal margin with ventral margin sharply rounded. Valve angulated along a line from umbo to junction of posterior with ventral margin. Surface ornamented with obscure concentric folds and very fine radials; valve-margin crenulated. Escutcheon well marked, bounded by a ridge. Dentition not clear; there are 8 or 9 small teeth anterior to beak, but the only valve showing dentition is broken posteriorly.

Height, 3.0 mm.; width, 3.5 mm.; inflation (2 valves), about 1.6 mm.

The material consists of paired valves (holotype) and a broken paratype.

Nuculana (Saccella) duplicarina n.sp. (Fig. 2).

Probellula Marwick is the only Neozelanic species with which this form need be compared. The two are very similar indeed in outline and in sculpture, the concentric ridges of *probellula* being only a little coarser and more numerous. The Pakaurangi shell has the

beak a little fuller. In hinge characters there is no observable difference. They can, however, be separated at a glance in that *duplicarina* has two distinct folds running from the umbo posteriorly, the upper one ending at the rostrum and the lower one diverging from the upper and sweeping out to ventral margin some little distance away from beak. Just posterior to beaks the shell rises in two steps from hinge margin to outer surface of valve, and on these steps concentric sculpture is absent.

Height, 4.4 mm.; length, 7.1 mm.

Four specimens were collected. This is probably the "*Leda semiteres* Hutton" of Marshall's list, but is distinct from *semiteres* at a glance owing to different outline.

***Nuculana (Jupiteria) parleachi* n.sp. (Fig. 6).**

There are two fully adult shells and a dozen or so immature ones that come closer to *leachi* Marwick, a fossil from Gisborne District, than to any other species. The Pakaurangi shells are very inflated, more so than *leachi*, and have the beaks a good deal fuller. The posterior dorsal margin descends more rapidly in *leachi* and the beak is not so blunt and is lower down. *Leachi* has the ventral margin regularly convex, whereas *parleachi* has it straightening out posteriorly. The angulation separating the posterior end from the lateral surface of the valve is scarcely defined in the Pakaurangi Point species, and does not extend to the extremity of the rostrum. The adult is smaller than that of *leachi*.

Height, 4.5 mm.; length, 6.9 mm.; inflation, 1.8 mm. Corresponding dimensions of *leachi*: 5.1, 7.7, 1.9.

Many shells of this species have been collected. The juveniles are more similar in outline to *leachi* than are the adults. No form corresponding to this occurs in Marshall's list.

***Nuculana (Jupiteria) vadosa* n.sp. (Fig. 1).**

Shell small, little inflated, elongate, beak in front of middle, not much raised. Posterior dorsal margin long, convex, slowly descending to pointed rostrum which is very low down; ventral margin lightly convex; antero-dorsal margin almost straight; anterior margin rather quickly rounded. Sculpture of growth-striae with more or less regularly spaced concentric grooves; beaks smooth. Hinge moderately heavy, 10 to 11 teeth both in front of and behind beak; resilium small, distinct. Pallial sinus seems to be shaped like an inverted V, the anterior limb descending almost vertically from anterior end of muscle-scar.

Height, 2.1 mm.; length, 3.6 mm.

A pair of valves was collected. The elongate shape at a glance separates it from other Neozelanic species.

***Ledella clifdenensis* Powell.**

1935. *Proc. Mal. Soc.*, vol. 21, pt. 4, p. 254, pl. 27, fig. 7.

There are 45 shells that match Clifden ones perfectly. This constitutes a new record for these beds.

"Arca" mundeformata n.sp. (Figs. 10, 11).

Shell small, elongate, beaks a little in front of anterior fourth, small, incurved. Posterior height greater than anterior height. Dorsal margin straight; posterior one convex; valve considerably drawn down postero-ventrally; ventral margin almost straight, with a light concavity at about its middle; anterior margin regularly rounded. Hinge with teeth developed along whole length; teeth vertical in centre, converging ventrally at extremities. Cardinal area narrow, smooth anteriorly, but with several weak oblique grooves towards posterior. Valve margins crenate towards posterior. Sculpture of numerous fine radials and concentric ridges of equal strength to the radials over anterior two-thirds, giving a close regular fenestration of squares; posterior third with strong, regular radials, the concentric ridges here practically obsolete.

Height, 6.0 mm.; length, 9.0 mm.

Two sets of valves have been obtained. This species is in the meantime referred to "*Arca*," as the writer has not been able to refer it satisfactorily to any of the subgeneric groups discussed by Reinhart.* This is apparently the "*Arca novae-zelandiae* Smith" of Marshall's list.

Glycymeris (Grandaxinea) finlayi n.sp. (Figs. 13, 24).

Shell large, very like *G. laticostata* in outline. Radial ribs about 40, rounded, weakening towards ventral margin. Ribs narrower, more rounded towards posterior end of valve, as has been remarked by Marwick (*Trans. N.Z. Inst.*, vol. 54, p. 64, 1923) for *laticostata*. Ligamental area wide and high, with many chevrons (11 ridges as against 6 in *laticostata* of same dimensions). Valve very convex, much more inflated than *laticostata*, and the posterior umbonal fold rather better defined. Hinge and teeth very alike in both species.

Height, 68.0 mm.; length, 61.0 mm.; thickness, 23.0 mm.

Localities: Clifden, Southland, roadcutting half a mile behind racecourse (= bed 7c along the river); Pakaurangi Point, Kaipara. The type is from Clifden.

There are six small valves (15 mm. in height and less) from Pakaurangi. These do not appear to be adult and they resemble closely the early stages of the Clifden shells. The radials and interstices alike are crossed by many fine concentric threads, and similar concentric sculpture is present in the early stages of growth of the Clifden specimens also. These small shells are no doubt the "*Glycymeris* sp. B" of Marwick (*loc. cit.*, p. 67, pl. 1, figs. 5, 6), and may yet have to be separated out as new.

Easily distinguished from *laticostata* by the very much more inflated valve, the more numerous chevrons, and the better elevated and more convex radials. Also the ligamental area cuts the plane of contact of valves more obliquely. *G. monsadusta* Marwick has a heavier hinge and much more prominent beak than either *laticostata* or *finlayi*.

* Classification of the Pelecypod Family Arcidae, *Bull. du Musée royal d'Histoire naturelle de Belgique*, 11, 13, 1935.

This species is named in honour of Dr H. J. Finlay.

Glycymeris (Glycymerita) marshalli Laws.

1930. *Glycymeris marshalli* Laws, *Trans. N.Z. Inst.*, vol. 61, p. 547, pl. 91, figs. 13, 14.

1937. *Glycymeris (Glycymerita) thomsoni* Marwick, *N.Z.G.S. Pal. Bull.*, no. 15, p. 22.

Finlay and Marwick (*N.Z.G.S. Pal. Bull.*, no. 15, p. 22, 1937) regard this species as identical with *thomsoni* Marwick. There is, however, no doubt whatever that the forms are distinct species. *Marshalli* is to be distinguished from *thomsoni* by its very much lighter build, more oblique valve, considerably less inflation, much less pronounced and less incurved beak, lighter hinge with more numerous and much finer teeth, which are not so horizontal as those of *thomsoni*, less prominent fold running externally from beak to posterior margin, and notable decrease of inflation towards ventral margin.

Dimensions—*Marshalli*: height, 67 mm.; length, 74 mm.; inflation, 24.5 mm. *Thomsoni*: 74.5 mm.; length, 74.5 mm.; inflation, 34.0 mm.

Limopsis propeinvalida n.sp. (Fig. 7).

Shell very small, oblique, beaks low, hinge rather heavy. Sculpture of thin, low concentric ridges with wide, flat interspaces. These are crossed by fine radial threadlets which feebly nodulate the ridges at intersections. Hinge with four teeth on either side of the wide triangular ligament pit, the posterior set with their long axes horizontal, the anterior set vertically disposed. No teeth below ligament area, which meets edge of hinge.

Height, 4.0 mm.; length, 3.4 mm.

The material consists of odd right and left valves and a paratype.

Distinct from *invalida* Marwick, a fossil from Chatham Islands, in sculpture, disposition and number of teeth, rather wider ligament pit, and greater obliquity. *L. tenuis* Marshall, though small, is a shell of different proportions. This is the first record of the genus from Pakaurangi Point.

Hochstetteria n.sp.

Six valves have been collected, but none of them are good enough for description, and further they seem very close to a new species from Target Gully, which the writer has named in manuscript in a paper shortly to be presented for publication. New record for these beds.

Cratis ovata Marwick.

1931. *Cratis ovata* Marwick, *N.Z.G.S. Pal. Bull.*, no. 13, p. 60, figs. 28, 31.

There are 8 valves. The only difference from *ovata* seems to be in the dentition. Marwick states that there are four transverse teeth behind the ligament pit. The Pakaurangi shells never have more than three, and some of them show only two. Since Marwick had only one valve for his description, and since the fossils from Pakaurangi themselves vary in this respect, the only course is to identify them as above.

Pallium (*Mesopeplum*) *kaiparaense* Finlay.

1918. *Pecten subconvexus* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 273, pl. 22, figs. 4, 5, 6.

1924. *Pallium (Felipes) kaiparaensis* Finlay, *Proc. Mal. Soc.*, vol. 16.

This species is very close to *costato-striatum* Marshall from the same beds and described on the same page. Examination of Marshall's material and of that procured by the writer shows that *kaiparaense* does not grow so large and has finer and more numerous radials. Two of the shells figured by Marshall as *subconvexus* (*loc. cit.*, pl. 22, figs. 5 and 6) should be identified as *costato-striatus*; thus the shell represented by fig. 4 remains to become the holotype, no type-designation having been made at the time of description.

Pallium (*Mesopeplum*) *costato-striatum* (Marshall).

1918. *Pecten costato-striatum* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 273, pl. 22, figs. 1, 2, 3.

1928. *Pallium († Felipes) costato-striatum* (Marshall), Marwick, *Trans. N.Z. Inst.*, vol. 58, p. 454.

Three different right valves were figured by Marshall and no type-designation formally made in his paper. However, the specimen represented by fig. 3 has inside it the letter T made in pencil, and this no doubt indicates Marshall's selection of the holotype.

***Cyclopecten (Cycloclamys) shepherdii* n.sp.**

This is the first fossil species of the genus to be recorded from New Zealand. A single left valve has been obtained. Of the three recent species it is nearest to *C. aypouria* Powell, but *aypouria* is more nearly equilateral and has the beaks central and raised into rounded knobs. Also the radial threads of the new species are better developed and run through the concentrics.

Height, 1.0 mm.; length, 1.3 mm.

***Otenamussium vafer* Marwick.**

1931. *Otenamussium vafer* Marwick, *N.Z.G.S. Pal. Bull.*, no. 13, p. 64, figs. 55, 56, 57.

About 30 valves, right and left in equal numbers. Judging by Marwick's figures and description these are not separable from *vafer*. There is a closely similar form in the beds at Clifden, which may or may not be this species.

***Mantellum* sp.**

There is one valve of a small individual that cannot be distinguished from similar small shells from Awamoan beds at Ardgowan and Target Gully.

***Kidderia otamatea* n.sp. (Fig. 5).**

Shell very small, elongate, dorsal and ventral margins parallel, straight; posterior end lightly convex, descending obliquely posteriorly; anterior end pouting below beak, which is at about anterior fifth. Dentition obscure; there seems to be one or two minute denticles on hinge below beak. Externally there is a very well defined angulated ridge running from beak to postero-ventral margin, above which valve is distinctly winged. Surface unsculptured but for growth-striae and occasional weak corrugations.

Height, 1.1 mm.; length, 2.0 mm.

The type is a right valve. There are two paratypes.

This is the first fossil Neozelanic species of the genus to be described. The hinge is not unlike that of *K. campbellica*, which also has very weak cardinal teeth.

Salaputium tinopaica n.sp. (Fig. 9).

This is the second Neozelanic species to be recorded, *S. animula* (Marwick) being a fossil from Chatton. Shell small, beaks at anterior third, low, not prominently rising above dorsal margin; posterior end truncated, descending vertically; anterior end sharply rounded; low down; posterior dorsal margin long, straight, scarcely descending; anterior dorsal margin straight, rapidly descending. There is a broad, low fold extending from beak to junction of ventral and posterior margins; sculpture of concentric ridges, evenly spaced and about their own width apart. Left hinge much as in *animula*, but anterior cardinal sloping more anteriorly, and posterior one about vertical (slightly backward sloping in *animula*); along upper part of posterior of ligament depression there is a weak backwardly-directed ridge; posterior lateral straight, extending for three-quarters of dorsal margin. Right hinge with thin, sharply elevated, vertical cardinal; anterior lateral long, very thin, straight and parallel with margin; posterior lateral long, faintly curved; there is a low ridge on the upper part of the floor of the ligament depression. Valve-margins distinctly crenulated.

Height, 9.0 mm.; length, 11.0 mm.

The type material consists of odd right and left valves. There are 8 paratypes.

Easily separable from *animula* by the crenulated margins. Finlay (*Trans. N.Z. Inst.*, vol., 61, p. 256, 1930) separated this Pakaurangi Point shell out as new. He has stated (*loc. cit.*) that Australian forms of *Salaputium* have either smooth or crenulated margins.

Dimya n.sp.

This species is not described at present as better material is hoped for. There are 5 valves. This is the first record of the genus as a fossil in New Zealand, though it occurs in the Australian Tertiary.

Cardita kaiparaensis n.sp. (Fig. 17).

Externally similar to *C. aoteana* Finlay. Ventral margin straight, no byssal excavation. The ribs are the same in number as those of *aoteana*, and are disposed similarly; but they are narrower and are separated by shallower and wider grooves. The hinge is close to that of *northcrofti* Marwick. Anterior end straight; vertical; in *northcrofti* the antero-ventral border is thrust forward, and *aoteana* and *brookesi* have it considerably pouting. *Kaiparaensis* has the cardinal of the left valve not as vertical as that of *northcrofti*. Other differences from *northcrofti* are to be had in the pronounced posterior wing, narrower and more widely separated ribs and less conspicuous beaks.

Height, 6.0 mm.; length, 10.0 mm.; inflation (1 valve), 3.0 mm.

Type and two paratypes (left valves).

Eulopia (Notomyrtea) n.sp.

There is a single small left valve of an individual apparently not adult, but sufficiently distinct to be recognised as new. It is expected that more satisfactory material will be collected.

Notolepton sanguineum (Hutton).

After close comparison of a large series of Recent *N. sanguineum* with a large series of shells from Pakaurangi it has been found impossible to detect any divergent characters sufficiently constant to make it necessary to distinguish between them. If anything, the fossils are of slightly lighter build and the hinge not quite so heavy; and the posterior tooth in the left valve is generally better differentiated in the Recent forms. Individuals vary amongst themselves in much the same way and to much the same extent in the fossil series as in the Recent one. Thirty specimens (right and left valves) were obtained at Pakaurangi. *N. sanguineum* is not uncommon as a fossil in the Waitotaran beds at Kaawa Creek.

Rochefortula cf. kaawaensis Bartrum and Powell.

There are two small valves that offer no means of separation from the Kaawa Creek species.

Tellinella ferrari Marwick.

1931. *Tellinella ferrari* Marwick, *N.Z.G.S. Pal. Bull.*, no. 13, p. 75, fig. 92.

Two topotypes. They match very well indeed Marwick's figure and description. The sculpture is finer and more lamellar than that of Recent shells that are usually (though erroneously, *vide* Powell) identified as *eugonia* Suter.

This is no doubt the "*Tellina eugenia* Suter" of Marshall's list, the species-name being mis-spelt in the list.

Angulus (Peronidia) inflata n.sp. (Fig. 4).

Shell small, inequilateral, beaks behind middle, valve broadly rounded in front, angled behind. Anterior dorsal margin lightly convex, slowly descending; posterior dorsal margin straight, descending rapidly, angulated at junction with ventral margin, which is convex. Valves rather inflated.

Height, 11.0 mm.; length, 17.0 mm.; inflation (two valves), 6.0 mm.

The type is the only specimen. Separable from already described Neozelanic species by smaller size, distinctly greater inflation, more convex ventral margin, and posterior position of beak.

Nemocardium (Pratulium) n.sp.

This is certainly not *pulchellum* Gray, as listed by Marshall. It is inflated much like *semitectum* Marwick from Lorne, and has a similar strongly incurved beak. *Finlayi* is a more coarsely sculptured species; nor can it be referred to any other Neozelanic species. The hinge is covered with matrix which cannot be removed.

Hiatella cf. australis (Lam.).

There are three small valves that it is quite impossible to separate specifically from Pliocene and Recent individuals of similar size.

GASTEROPODA.

***Scissurella condita* n.sp (Fig. 74).**

Shell minute, nucleus depressed below level of later whorls, umbilical depression well differentiated, whorls enlarging rapidly. Early post-nuclear volution with strong, sharply elevated axials but no spirals; on second whorl spirals appear, 5 or 6 in number, and these are fine but distinct threads, irregularly spaced, and over-ridden by the axial ribs, which now become a little sinuous. On this whorl the slit-fasciole has its beginning, its edges turned up into sharp lamellae. The fasciole is situated about one-third of distance between periphery and suture. Periphery strongly convex. Base convex, with about 24 conspicuous, sinuous axials converging into umbilical depression. Below slit-fasciole the spirals are fine and closely spaced; on base they are coarser, spaced about their own width apart, and entirely over-ridden by the heavy axial costae. Aperture with its top margin straight and horizontal, the remainder of the peristome U-shaped. The axials weaken and tend to become crowded together towards aperture.

Height, 0.4 mm.; diameter (greatest), 0.9 mm.

There is the holotype along with two juvenile paratypes. The wide umbilical hollow is not typical of *Scissurella*.

***Schizotrochus miocenica* n.sp. (Fig. 48).**

Shell small, trochiform, thin, narrowly umbilicate. Spire gradate, about three-fourths height of aperture. The double peripheral keel with sharp lamellar edges. Sculpture of fine hair-like curved radials, over both upper and lower surfaces. Also on both surfaces there are thin, hair-like spirals, widely and evenly spaced, 7 or 8 in number on penultimate whorl. The umbilicus is partly hidden by the reflected inner lip. The interval between the two lamellar ridges of the peripheral keel is crossed axially by numerous hair-like ridges, concave towards aperture. Peristome continuous, outer lip with notch at junction with anal slit, which runs back for half distance around body-whorl.

Height, 1.6 mm.; width, 1.7 mm.

Besides the holotype there are 16 paratypes, many of them not adult.

This is the first fossil species of *Schizotrochus* to be recorded from New Zealand. It is closest to *S. finlayi* Powell, a Recent shell taken in deep water off Three Kings Islands.

***Emarginula komitica* n.sp. (Fig. 40).**

This species possesses the open lattice effect of *galeriformis* and *paucicostata*. The latter, however, is a smaller and flatter species, but *galeriformis* bears a strong resemblance to the shell being described. These two species agree in the number of primary ribs, but *komitica* has the ribs crowded with low, dense, close scales and more regularly spaced. The concentrics are regular and are evenly spaced. In profile the new species is seen to have the beak more strongly curved over, and the posterior slope considerably more excavated just below beak; consequently it rises from posterior margin much less steeply. *Galeriformis* has weak secondary ribs sporadically de-

veloped, whereas these are a regular feature of the ornament of *komitica*. In form *komitica* is not unlike the Pliocene and Recent *striatula*, but *striatula* has the beak not so far back, and the ribbing is different.

Height, 4.0 mm.; length, 6.6 mm.; width, 4.5 mm.

Seven specimens were collected.

***Emarginula kaiparica* n.sp. (Fig. 38).**

This distinct species has the outline more of *Tugalia*, being more elongate than other local *Emarginula*, and having the sides straighter and longer, the shell being drawn out towards the anterior. In sculpture it is closest to *striatula* Q. and G., but is not so elevated and has the beak further back. There are about 18 primary ribs on each side, between each pair of which there is a thin, distant secondary rib. Fine, closely spaced concentric threads fenestrate the spaces between radials, which they faintly nodulate at intersections. *Striatula* has the sculpture coarser and more open. In profile *kaiparica* has the anterior slope more gradual and more evenly convex, the beak much lower and rather nearer the posterior, and the posterior slope shorter and straight. The slit of *striatula* does not penetrate as far as that of *kaiparica*. *Pittensis* has the sculpture coarser than that of *striatula*.

Height, 3.0 mm.; length, 8.5 mm.; width, 5.0 mm.

Five specimens were collected.

***Maurea* sp.**

A dozen or so juvenile specimens and apices. Not those of *M. gracilis* from the same beds.

***Zetela hutchinsoniana* n.sp. (Figs. 57, 58).**

Shell small, conical, narrowly umbilicate, spire a little higher than aperture. There are $3\frac{1}{2}$ whorls excluding the protoconch. Protoconch bulbous, of one volution, unsculptured. Early post-embryonic whorls crossed by thin, sharp axial lamellae. On second post-embryonic whorl two spirals appear, angulating the whorls, one just above periphery, the other midway between the first spiral and the posterior suture. These spirals are hardly as strong as the axials at this stage. On the body-whorl there are 6 axials, the first below suture rather weak, the next two (on periphery) the strongest, and three weaker ones on the base; then follows the nodulated circum-umbilical cord. Axials on all adult whorls lamella-like, about 20 on last whorl; those on base, however, very weak and threadlike. Nodules produced at intersections of axials and spiral cords. Base lightly convex. Suture channelled. Width of umbilicus about one-fourth that of shell.

Height, 1.5 mm.; width, 1.5 mm.

Five specimens collected.

Nearest to *Z. praetextilis* (Suter) but smaller, has not the striated protoconch, has fewer spirals on base and the circum-umbilical cord much weaker and not so heavily gemmate. *Textilis* (Murdoch and Suter) has a much wider umbilicus.

Zetela parvumbilicata n.sp. (Fig. 56).

Very close to *Z. hutchinsoniana* n.sp. but with the spire more elevated and the sculpture heavier, and the umbilicus very much less open. The protoconch is true to type, but is not quite so small as that of *hutchinsoniana*. The first post-embryonic whorl has low, coarse axials and no spirals. On next whorl two heavy spirals cause reticulation of sculpture and also heavy nodules where they cross the axials. On the body there are 6 strong widely and regularly spaced spirals, two above periphery, one (the strongest) on periphery, and three on the base, these last becoming progressively weaker towards umbilicus. There are about 25 axials on the body-whorl. The umbilicus, which is very narrow, is enclosed on the left by the last (seventh) of the spiral cords. Suture strongly canalliculate. Base lightly convex.

Height, 3.9 mm.; width, 3.8 mm.

Three specimens were collected.

The feebly developed umbilicus distinguishes this species at a glance from all others.

Zetela awamoana n.sp. (Fig. 78).

Shell larger than that of *hutchinsoniana* n.sp. and more finely sculptured. Spirals always stronger than lamellar axials, which are exceedingly numerous and close together on the body. Penultimate whorl with three spirals, the upper one weak; body-whorl of immature shells with three spirals above periphery, one on periphery, and one fairly heavy one immediately below it; then comes a wide zone that appears smooth, but in reality has about four weak, flattened spirals; in fully adult shells the body carries about 12 well-developed spirals which are gemmate, but there are no axials developed in their interspaces. The circum-umbilical cord sweeps well around and is heavily nodulated; within the umbilical depression there are three or four weak cords entering umbilicus spirally. Protoconch smooth, of one volution. On first post-embryonic whorl spirals and axials appear. Suture impressed, not channelled; whorls convex and not angulated.

Height, 2.3 mm.; width, 2.5 mm.

Locality: Pukeuri, Oamaru (Awamoan), common.

Certain fragments show that this species grows to a larger size than that indicated by the type.

Antisolarium tricarinatum n.sp. (Figs. 29, 30).

Shell small, of three whorls, the last increasing rapidly in width; depressed (height of spire one-third that of aperture), flat on top; embryo tiny and coiled closely. A keel develops on first post-embryonic whorl at about anterior third; four spiral threads soon appear above the keel; on the body whorl these threads have developed into broad, low cords. In addition there are three smooth, strong, sharply elevated spiral cinguli around peripheral bulge of the body, the uppermost (the weakest) being the one originally traced on the spire; the middle one emerges at aperture from the suture and the lower one close beneath it. These three cords are equidistant and

the lower two are sub-equal in strength. In the flat-floored spaces between the three heavy spirals there are several very fine spiral threads. The base is very lightly convex and carries six low spirals, plus a heavy rather nodulated cord around edge of umbilical depression. Four or five fine spiral threads are present within umbilical hollow. Axial sculpture is confined to a few low growth-folds on the body extending obliquely from posterior suture towards the upper heavy cord. The features of aperture and pillar are entirely those typical of *Antisolarium* and *Conominolium*. The pillar is strongly sinuous, and from it a thin distinct ridge enters the umbilicus spirally. In the Waitotaran *A. conominolium* this ridge is not so thin and cord-like, and in the Recent *A. egenum* it is still less visibly developed, being but a broad low fold. The outer lip is denticulated by the heavy peripheral spirals.

Height, 2.6 mm.; greatest diameter, 3.4 mm.; least diameter 2.7 mm.

The holotype is the only specimen.

This species is referred to *Antisolarium* rather than to *Conominolium* in view of its depressed habit and few strong keels. Also the aperture and pillar agree better with those of the former genus. It lacks the broad smooth band on the base found in the type-species; but *A. conominolium* from the early Pliocene also has spirals on the base, though they are extremely weak and tend to be obsolete towards its outer edge. There is a greater difference between the Hutchinsonian and the Waitotaran forms than there is between the Waitotaran and the Recent ones. It is to be expected that the discovery of further ancestral species (possibly in the Awamoan) will help to connect *tricarinatum* with the lower Pliocene species.

This may or may not be the form recorded by Marshall (*loc. cit.*, p. 273) as *Solariella stoliczkai* Zittel. There is also a new species of *Conominolium* in the same beds, and it is possible that this may have given rise to the record of *stoliczkai*.

***Lodderia kaiparaensis* n.sp.¹**

Shell very small, umbilicate, spirally ribbed and axially costate; whorls enlarging rapidly. Protoconch of one smooth turn ending at a low indistinct varix. The first post-embryonic whorl develops three spiral keels crossed by axial ribs that are weaker than the keels, though they cause nodulation at points of intersection. These keels angulate this whorl. On the body the axials and spirals are equal in strength, causing an open reticulation. Both elements of sculpture consist of thin sharply elevated ribs, spaced well apart. The body-whorl has five spirals, the first distant from suture, the last forming a prominent cord around umbilical depression. The axials are continued as thin threads down into this depression. Umbilicus moderately wide. Features of aperture similar to those of *L. eumorpha* (Suter).

Height, 0.9 mm.; width, 1.0 mm. (greatest).

One specimen only.

¹ A figure will be given in the next paper of the series.

This and *L. komitica* n.sp. are the first *Lodderia* to be found fossil in New Zealand, all previously recorded forms belonging to the Recent fauna. Both are separable from *eumorpha* at a glance on account of the few widely spaced and comparatively heavy axials. In *eumorpha* the axials are much more numerous and less conspicuous.

***Lodderia komitica* n.sp. (Fig. 41).**

This species has a larger protoconch than *kaiparaensis* and no heavy spirals on the first post-embryonic whorl, but there are numerous thin, flexuous axials. This whorl is convex and not angulated as in *kaiparaensis*. On the body there are 6 spirals, the posterior some distance from suture, the next (strongest) on the periphery, and the third below that. On the base the remaining two keels are very weak and the axials are mere indistinct threads. The last spiral forms the border to the umbilical depression, and is not as well defined as that of *eumorpha* or *kaiparaensis*. On the body the axials are thin, well defined but more numerous than those on the other Pakaurangi fossil. The peristome is continuous, circular; columella thin, long, arcuate; umbilicus narrow, much more so than in either *eumorpha* or *kaiparaensis*.

Height, 0.9 mm.; width (greatest), 1.0 mm.

One specimen was collected.

***Elachorbis* n.sp.**

A single very well preserved but immature specimen. Further collecting will probably bring to light a larger shell.

***Lissotesta alpha* n.sp. (Fig. 34).**

Shell minute, of three post-embryonic whorls, resembling *L. benthicola* Powell very closely indeed in build and shape of whorl. *Alpha*, like *errata* Finlay, has spirals present generally over surface and also in the umbilicus, whereas *benthicola* has them limited to the base, and a single one as a margin to suture. *Alpha* is rather taller than *errata*, and has the suture in no sense canaliculate, and is a smaller more delicately built shell. *L. granum* (Murdoch and Suter) has no spiral sculpture and is broader across the body in relation to height of shell. *Rissoaformis* Powell, though similar in shape, is larger, more heavily built and has much coarser spirals. *Canoidea* Powell is much taller spired and has more whorls and the umbilicus better defined. The Awamoan *L. exigua* (Suter) is a larger species with the body-whorl a good deal wider in relation to height. *Alpha* has a low ridge bordering the umbilicus.

Height, 1.1 mm.; width, 1.0 mm.

One specimen was obtained.

Prior to the present record the Awamoan marked the earliest known appearance of *Lissotesta* as a fossil in New Zealand.

***Lissotesta beta* n.sp. (Fig. 37).**

Shell minute, a shade smaller than *alpha* n.sp., to which it is very similar in shape and build. It differs from *alpha* in smaller protoconch, narrow early adult whorls, lack of spiral sculpture and of ridge bordering umbilicus, and suture below periphery, the whorls

almost tabulated. Also the whorls are strongly and evenly convex. There is a suggestion of a blunt angle encircling body just below periphery.

Height, 1.0 mm.; width, 0.9 mm.

One specimen collected. A perfectly preserved little fossil.

Lissotesta n.sp.

Very near to *L. tenuilirata* Powell, but much smaller. The specimen is not adult and more suitable material is awaited before naming the species.

Dolicrossea clifdenensis Finlay.

Two specimens, somewhat smaller than the Clifden shells, but undoubtedly conspecific. Probably the "*Crossea labiata* Suter" of Marshall's list.

Dolicrossea atypica n.sp. (Fig. 61).

Shell very small, height of spire about equal to that of aperture. Whorls strongly convex. Protoconch of one smooth turn, convex over summit. First few whorls distinctly broadly tabulated around suture, the edge of tabulation forming an angle or keel. Surface unsculptured; growth-lines strongly retracted from upper suture. Aperture circular, not notched below. Small umbilicus present with a deep narrow crescentic furrow entering it. There is no heavy cord bordering left side of furrow as in *clifdenensis*, but a low, ill-defined fold takes its place, the lower extremity of which causes inner edge of basal lip to protrude slightly, though not at all pointed as in other Neozelanic species.

Height, 1.5 mm.; width, 1.3 mm.

Three specimens collected. Distinct at a glance from any other Neozelanic species of *Dolicrossea*.

Crosseola tenuisculpta Laws.

1936. *Crosseola tenuisculpta* Laws, *Trans. Roy. Soc. N.Z.*, vol. 66, p. 104, pl. 16, fig. 57.

There are three shells, one of them adult but rather worn, that cannot be distinguished from the above species, apart from the fact that the Pakaurangi shells have a slightly smaller embryo. In outline and build of whorl the Kaawa specimens agree entirely with those from Pakaurangi.

Crosseola sinemacula n.sp. (Fig. 66).

Shell very small, whorls strongly and evenly convex. Protoconch of one volution, smooth, depressed. Both axial and spiral sculpture developed, but texture though fine is very clear. Thin, sharply elevated axials appear first. The first spiral appears as a carina around centre of first post-embryonic whorl; shortly a second spiral comes in below, and then a third below that. The axials are antecurrent to upper suture. Axials and spirals of equal strength; sculpture of spire-whorls and upper part of body thus fenestrated. On body axials weaken at about periphery, but spirals are developed over whole surface. The penultimate whorl carries four spirals, the

upper one weak. On the body-whorl there are about 20 regularly spaced spirals. Towards the umbilical rib spirals are absent, only the ribs now in evidence. Umbilical rib crenulated. Aperture circular. Pillar thick, heavy, widening below, with a narrow notch below it.

Height, 2.0 mm.; width, 1.8 mm.

The type is the only specimen. This is an exquisite little shell, in a state of perfect preservation. The very fine, regular sculpture distinguishes it. *Errata* Finlay has only six cords on the body, and these are stronger than those of the Pakaurangi Point species; *proerrata* also has fewer and heavier ribs, and further the axials over-ride the spirals. Also the fasciolar cord makes a more pronounced sweep over base, whereas in *sinemacula* it more or less enfolds the columella and is set vertically.

***Orbitestella praetoreuma* n.sp. (Figs. 15, 16).**

Shell tiny, discoidal, widely umbilicate. Whorls biangled by two strong spiral keels. Protoconch of one smooth volution. Umbilicus perspective, about one-third greatest diameter. Spire a little sunken. Very heavy axial ribs are prominent on all whorls. On the upper surface of body-whorl these are strongly elevated and almost tooth-like. Towards the edge of upper surface they descend rapidly into a circular groove and then appear again on the strong peripheral cord as pronounced denticles. Immediately below this cord the vertically descending side of body is excavated and axials are not developed in this depression. The cord encircling the outer edge of the base is also denticulate. A spiral depression encircles its inner edge and then the base rises into a broad, convex zone carrying very heavy, thick radial costae, whose inner ends tend to overhang the umbilical hollow. Aperture very like that of *O. toreuma* Powell.

Height, 0.2 mm.; diameter (greatest), 0.6 mm.

Two specimens collected. Easily distinguished from *toreuma* by the very heavy, prominent axial sculpture.

***Orbitestella praehinemoea* n.sp. (Figs. 20, 21).**

This shell is closely similar in many respects to *O. hinemoea* Mestayer. In the development of umbilicus and in sculpture of base the two forms are practically identical. If anything, the fossil has the umbilical depression a little wider. On the upper surface *hinemoea* has the spire slightly stepped, that of the fossil being perfectly flat, so that the suture becomes simply a linear groove. The numerous retrocurrent radials of *hinemoea* are represented in *prae-hinemoea* by low, irregular corrugations. The periphery is marked by a strong spiral cord, slightly nodulated above by the axial corrugations. This upper cord is separated from the lower one situated at angle leading on to base by a deep, narrow groove. Base convex and carrying coarse axial corrugations which sharpen somewhat towards inner ends. Disc very thin.

Height, 0.2 mm.; diameter (greatest), 1.0 mm.

One specimen collected. Separable at a glance from *hinemoa*, which has a single strong keel around centre of the vertically descending party of body-whorl, the fossil species, on the other hand, having a deep groove in the position of the keel on *hinemoa*. Otherwise there is a good deal of likeness between these two species.

These are the first fossil species of *Orbitestella* to be described from New Zealand, at least.

***Zeradina aculeata* n.sp. (Fig. 49).**

Shell small, spire high and narrow; apex sharpened; height of spire about one-third that of body-whorl; whorls convex, suture well cut in, a little channelled. Protoconch pointed, of about two volutions, with fine axial lamellae just below suture for a short distance, spirals developing on lower half of last volution. Body-whorl very long, convex in a broad sweep from suture to base. Aperture ovate; outer lip effuse below; inner lip separated from body anteriorly by a groove. Columella long, thin, arcuate, set vertically. Axial sculpture other than rude growth-plications is lacking, except on the first adult whorl where there are thin, curved axial lamellae dependent a short distance from suture. Irregular weak spiral ridges and grooves are present over surface of all whorls, none of these spirals being consistently more in evidence than others.

Height, 3.2 mm.; width, 1.5 mm.

Type and two immature paratypes collected. Related to *Z. producta* (Odhner).

***Zeradina* n.sp.**

Two immature shells that may be compared with *Z. ovata* (Odhner) and *odhneri* Powell.

***Zeradina (Radinista) vivienneae* n.sp. (Figs. 53, 55).**

Shell small, body-whorl very large and expanded, height of spire about one-fifth that of shell. Suture strongly cut in. Whorls convex, shouldered above. Protoconch of about $1\frac{1}{2}$ convex volutions, unsculptured. Sculpture similar to that of *Z. corrugata* Hedley, coarse growth-ridges simulating varices, and spiral threads which are rather uneven in strength. Aperture large, broadly ovate, continuous, inner lip separated from body by a groove; umbilicus distinct, entering from groove; a sharp ridge bordering left side of groove below and entering umbilicus.

Height, 2.0 mm.; width, 1.5 mm. Corresponding dimensions of a paratype (estimated): 2.8 mm.; 2.0 mm.

Type and three paratypes collected. Not so loosely coiled as *corrugata*, but it has similar development of furrow, inflated body and paucispiral, though not so sharply pointed, protoconch.

***Zeradina (Radinista) exilis* (Murdoch).**

1900. *Lacuna exilis* Murdoch, *Trans. N.Z. Inst.*, vol. 32, p. 220, pl. 20, fig. 3.

1926. *Zeradina exilis* (Murdoch), Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 376 (provisional location).

Lacuna exilis Murdoch from the Pliocene of Wanganui is extremely close to *corrugata*; in fact some little study is required in order to satisfy one's self of the separate specific identity of these

two forms. So far as the writer is aware *exilis* is known only from the unique holotype, which Mr. Grant has kindly sent for inspection. Finlay (*loc. cit.*, p. 376) provisionally located *exilis* along with *ovata* (Odhner) and *producta* (Odhner) in *Zeradina* s.str., and erected the subgenus *Radinista* for *Couthouyia corrugata* Hedley. There is no doubt whatsoever that *exilis* and *corrugata* are congeneric.

Couthouyia concinna Marshall and Murdoch, an Awamoan fossil from Target Gully, Finlay associated with *ovata*, *producta* and *exilis* in *Zeradina* s.str. Inspection of the holotype, however, shows *concinna* requires to be separated at least subgenerically from both *ovata* on the one hand and *corrugata* on the other. Its embryo is at once different, being polygyrate, conical with minute nucleus, and is reticulated. Superficially the furrow bordering the inner lip is akin to that of the *ovata* line, but a specimen of a closely allied form (*jocelynae* n.sp., described below) from Pakaurangi, having the callus removed from the inner lip, shows the *Radinista* ridge and deep furrow entering the umbilicus. In general build of shell and expanded body *concinna* resembles *corrugata*, but *concinna* has axial lamellae well developed on all whorls, and this seems not to be a feature of *Radinista*. The new name *Naridista* is provided, with *N. jocelynae* n.sp., as type, to cover shells like *concinna* Marshall and Murdoch and *jocelynae* n.sp., and is here given subgeneric rank under *Zeradina*.

One wonders what shell Suter (Manual, p. 193) used for his description of *C. corrugata*, for he describes the protoconch as "microscopically obsoletely reticulated," and this is reminiscent of *concinna* and *jocelynae*. Also Suter's figure of *corrugata* (Atlas, pl. 35, fig. 15), which seems not to be a copy of Hedley's illustration, shows axials well developed.

Genus ZERADINA Finlay.

Type (o.d.): *Naridista jocelynae* n.sp.

Subgenus *Naridista* n.subgen.

Type (o.d.): *Fossarus ovatus* Odhner.

This new subgenus is provided for shells having the ridge and furrow entering the umbilicus as in *Radinista*, but differing from *Radinista* in the character of the embryo, which is polygyrate, conical, with minute nucleus, and is reticulated. Axial lamellae are developed on all whorls.

Zeradina (*Naridista*) *jocelynae* n.sp. (Fig. 51).

Shell small, apex sharp, body very dilated, whorls convex, sutures very distinct. The protoconch is of about three volutions, and has four coarse threads around lower half of whorls, the whole width between sutures crossed by microscopic, hairlike, oblique axial threadlets. Subsequent whorls are crossed by thin, well elevated, very distinct spaced axials, antecurrent to upper suture. Axials extend entirely across body-whorl, converging on the umbilical area. Spiral sculpture in the form of evenly spaced axial threads is present in inter-axial furrows, and these rise on to the flanks of the

axials. Spirals spaced more closely than the axials. Aperture broadly elliptical; outer lip very effuse. Peristome continuous, separated from body by a narrow groove. Where parietal callus happens to be stripped away the groove is seen to be sharply ridged along its left border, deep and connected with umbilicus.

Height, 1.7 mm.; width, 1.0 mm.

The type and a fragmentary paratype were collected. *Jocelynnae* has more numerous and sharper axial lamellae and more expanded outer lip than *concinna*. The paratype consists of the body-whorl of a larger specimen than the type. The writer has a further n.sp. of *Naridista* from the Waitotaran beds at Kaawa Creek.

***Zeradina costellata* (Hutton).**

1885. *Achis costellata* Hutton, *Trans. N.Z. Inst.*, vol. 17, p. 319, pl. 18, fig. 14.

1926. *Zeradina costellata* (Hutton), Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 376 (provisional location).

Through the courtesy of Mr. R. A. Falla the writer has been enabled to examine the type-material on which this species was founded (a very well preserved holotype and an immature fragmentary paratype). *Costellata* is very close indeed to *Z. producta* in build and shape of whorls, features of aperture and umbilical groove, and in embryonic characters. The body-whorl, however, is fuller in *costellata*, but not so expanded as that of shells falling into *Radinista* and *Naridista*. It is distinct at a glance by reason of the obvious spiral cords. Weak axials are present also, and these fenestrate and slightly nodulate the upper few spirals. The spiral cord on the edge of the shoulder of the body-whorl is the strongest. Hutton describes the whole of the base as being "very finely spirally grooved." This is hardly precise. The grooves between the shoulder and the line of suture of body whorl (5 in number) are practically linear; but below the line of suture they open out considerably, becoming increasingly wider apart towards the anterior. The cords likewise become coarser. There are four grooves on base below line of suture.

***Argalista kaiparaensis* Finlay.**

1930. *Argalista kaiparaensis* Finlay, *Trans. N.Z. Inst.*, vol. 61, p. 56.

About 50 specimens have been obtained from sievings.

***Haurakia onerata* n.sp. (Fig. 54).**

Shell small, very stumpy, spire gradate, whorls convex; height of body nearly two-thirds that of shell. The body is inflated out of proportion to rest of shell. Protoconch of about two smooth turns. Sculpture consists of weak axials extending from posterior suture to about middle of whorls, then gradually evanescent. Body-whorl has a fine spiral groove around periphery. Aperture broadly ovate to circular. Outer lip heavily thickened externally. Columella thin, vertical, straight. There is a very tiny umbilical chink present. Parietal wall thinly callused.

—Height, 1.9 mm.; width, 1.4 mm.

Over 50 shells of this species were collected. The inflated body and weak development of axials are noteworthy.

***Haurakia sodalis* n.sp. (Fig. 63).**

This species is easily distinguished from *onerata* n.sp. in that it is not so stumpy, the body not being so inflated. The axials are almost obsolete, and in some specimens it is difficult to pick them up at all. Spiral sculpture of well-defined cords is developed on the base and weak spirals are present here and there elsewhere on whorls. There is a cord as a margin to suture around posterior of whorls. The suture is narrowly channelled. In the general build of shell, feature of aperture (swollen exterior to outer lip) *sodalis* agrees closely with *onerata*.

Height, 1.8 mm.; width, 1.0 mm.

Six shells were collected.

***Merelina saginata* n.sp. (Fig. 65).**

Shell very small, outlines straight, whorls lightly convex, suture not strongly cut in. Protoconch typical, spirally lirate. Whorls about $3\frac{1}{2}$ in number, ornamented by strong axials and equally strong spirals, the points of intersection of both elements of sculpture nodulated. Spire-whorls with three spirals each, the anterior two cords the heaviest and closer together. The posterior cord weaker and margining suture. Axials 10 to 12 on penultimate whorl, continuous from suture to suture, but dying out not far below periphery of body-whorl. Base with four heavy spirals below termination of axials, these cords not nodulated. Aperture roundly ovate, peristome continuous; basal lip broadly rounded; outer lip thickened externally, its sinus broad and shallow and not as well marked as that of Pliocene and Recent forms.

Height, 2.1 mm.; width, 1.1 mm.

Three specimens collected.

***Nobolira inflata* n.sp. (Fig. 69).**

Shell very small, spire gradate, whorls convex, body-whorl inflated. Whorls four plus protoconch, which is ornamented by seven fine spiral threads. Spire-whorls with two strong spiral keels, one around middle and the other not far above suture. Outline straight from posterior suture to upper cord. On penultimate whorl a very fine spiral thread borders posterior suture. On body-whorl a similar fine spiral appears from suture; base sculptured by fine spiral threads. Axial growth-striae present over whole surface. Aperture thickened outside by a very heavy rounded varix.

Height, 2.0 mm.; width, 1.0 mm.

Eighteen specimens collected. *Inflata* is close to *manawatawhia* Powell, but it has the suture more cut in, so that the spire is more gradate, the third and upper spiral of whorls is weaker, and there are five as against three basal spirals. *Charassa* Finlay is not so stout and has three keels on whorls of spire and four spiral threads on base. *Polyvineta* Finlay is larger, more elevated, and has four spiral keels on whorls of spire.

***Dardanula praecursor* n.sp. (Fig. 67).**

This species is remarkably like such Recent littoral forms as *olivacea* (Hutton) and *limbata* (Hutton). It also is very close to

the Awamoan *rivertonensis* Finlay, which up till now has been the earliest known species in New Zealand. The present record dates *Dardanula* back to Hutchinsonian times. Finlay (*Trans. N.Z. Inst.*, vol. 55, p. 491, 1924) has stated "it is interesting that a form (i.e., *rivertonensis*) so close to the Recent species should be abundant in a locality of this (Awamoan) age, when up till now it has been found nowhere else." A similar statement can be made with regard to *praecursor*, 43 specimens of which have been collected.

Rivertonensis is larger, has more pointed apex, rather better defined sutures, the periphery not so angled, and the outer lip drawn in towards axis. In *praecursor* the outer lip is in line of spire produced. *Olivacea* is a distinctly larger and more heavily built species. *Limbata* also is larger with better defined sutures and has not the periphery so angulate. *Praecursor* differs from both *olivacea* and *limbata* in having the aperture more oblique both from left to right and from front to back. In this respect it agrees with *rivertonensis*. Further, *rivertonensis* has the outline of spire faintly convex, that of *praecursor* being perfectly straight.

Height, 1.7 mm.; width, 1.0 mm.

***Brookesena duplicincta* n.sp. (Fig. 75).**

Shell minute, turreted, whorls bicarinate, strongly cut in to suture, height of body-whorl half that of shell. Protoconch with four heavy spiral keels. All adult whorls have two strong spiral keels with a thread above them bordering suture. There are thin, thread-like axials, spaced many times their own width apart, crossing spaces between spiral keels, to which they are always subsidiary. The base has one moderately heavy spiral cord below periphery and several very weak ones below that. Aperture broadly oval to rounded. Umbilical perforation not apparent.

Height, 1.0 mm.; width, 0.5 mm.

The type is the only specimen. *B. succincta* (Suter), which the writer has recently found fossil in the Waitotaran beds at Kaawa Creek, has one spiral more pronounced than the others, giving the whorls a medianly situated angle, whilst *B. neozelandica* (Suter) has at least three strong spiral cords per whorl, as well as other differences. *B. quadricincta* Marwick has a smooth protoconch.

***Nozeba perpava* n.sp. (Fig. 68).**

Shell very small, spire low, height of body-whorl over two-thirds that of shell. Whorls $3\frac{1}{2}$, lightly convex, rapidly increasing; suture distinct. Protoconch small. Body-whorl strongly convex, flattish on base. Aperture very broadly ovate; inner lip callused, basal lip very broadly rounded; outer lip effuse below, external varix present. Anterior notch broad, shallow. No spirals present on base. Umbilical chink narrow.

Height, 1.5 mm.; width, 0.9 mm.

Mica Finlay has grooves on the base, unthickened inner lip, pyriform aperture, suture margined.

***Socienna* n.sp.**

The apical whorls with the embryo of one shell is referable to this genus. Near to *S. exaltatus* (Powell).

Zaclys (Miopila) simulator n.sp. (Fig. 79).

Shell attenuate, outline straight, sutures indistinct. Each whorl has three equally strong and evenly spaced spirals, the upper and lower bordering sutures, the centre one around mid-whorl. These are crossed by numerous vertical axials (about 20 on body-whorl) spaced a little further apart than their own width, and of strength equal to that of spirals. Intersections of axials and spirals nodulated. Whorls considerably broader than high. The aperture is broken in all specimens. The columella bears a thin but distinct ridge low down. The protoconch is normal, tall, of about four convex volutions, unsculptured.

Height (estimated), 7.0 mm.; width (estimated), 1.5 mm.

Eight specimens collected. This species bears a striking resemblance to *Z. aequicincta* (Suter), there being very slight differences indeed in the sculpture. *Aequicincta* is more attenuate, has no plait, and generally has the middle spiral a little nearer posterior suture. In features of embryo, however, these two forms are subgenerically apart. This species is probably the "*Cerithiella fidicula* Suter" of Marshall's list.

Zaclys (Miopila) mucro n.sp. (Fig. 81).

Shell moderately attenuate, outlines convex, especially towards summit, sutures very indistinct. Sculpture similar to that of *simulator* n.sp., but axials not so strong, though the gemmules at intersection of spirals and axials are heavier. The reticulation of sculpture is not so open in this species, nor is the second spiral situated around mid-whorl, but higher up close to the posterior one. Spirals are thus not equally spaced as in *simulator*. Outer lip broken; columella with a low fold high up. The protoconch is much narrower and more sharply pointed than that of *simulator*, and consists of three to four convex, smooth volutions.

Height (estimated), 4.1 mm.; width, 1.0 mm.

Two specimens collected. No other recorded species of *Miopila* has the convex outline of this species.

Ataxocerithium sp.

Five apical fragments with the protoconchs in good condition.

Notosinister zespina n.sp. (Fig. 77).

This is a very strikingly ornamented shell, and although much of the spire is decollated, it is sufficiently distinct to be given a name. Each whorl is sculptured with two rows of spaced and very pronounced prickly granules, distinctly like tubercles, and standing out in unusually high relief. These are connected axially by low folds, and spirally by weak threads. The original spirals and axials have become suppressed, and the original granules have become accentuated as described. Base flattish, smooth, except for a thin spiral thread near its outer edge. Outer lip broken. Columella twisted, canal narrow.

Height (estimated), 7.5 mm.; width, 1.5 mm.

The type is the only specimen.

Notosinister n.sp.

Five fragments represent this new species. It is very close to *N. fascelina* (Suter), but the sculpture is not so heavy and the shell is of lighter build. *Fascelina* has the cord encircling outside of columella smooth, that of the Pakaurangi species being much lighter and moniliform. It is not unlike *N. insertus* Marwick, a fossil from the Chatham Islands. Protoconch not seen.

Notosinister sp.

Two apical fragments, one with the protoconch intact. *N. fascelina*, the type of the genus, has the embryonic whorls keeled medianly. In the present shell the first two whorls of the embryo are keeled low down, the following two being keeled by two cords running close together. Axial threads of protoconch as in the Recent species. The post-embryonic whorls remaining all carry two spiral rows of gemmules, but the fragmentary material available does not allow any closer discrimination than that above.

Triphora neozelanica n.sp. (Fig. 82).

Shell small, dextral, outlines practically straight, protoconch missing. Whorls flat, suture very indistinct, bordered by a strongly beaded cord. Anterior half of each whorl bears heavy, closely set, rather sharpened tubercles, arranged spirally and connected by a very light thread which crosses their summits and follows the saddles between them. The upper half or third of whorl is concave and unsculptured. Axial sculpture, which is indicated by vertical rows of tubercles, is seen to trend backwards towards upper suture. Body-whorl with a sharp angled periphery, on which are set heavy tubercles; base flat, not wide, encircled around its outer edge by a granular spiral, otherwise smooth, but slightly undulating. Aperture small, circular; peristome continuous, its edge raised up into a strongly projecting sharp rim. Anterior canal almost entirely closed to form a tube, strongly flexed in a dorsal direction, with two closely spaced threads encircling it externally. Outer lip sinused not far from suture. A little back from outer lip, on line of sinus, there is a very distinct, strongly projecting and slightly backwardly directed tube.

Height (estimated), 7.0 mm.; width, 1.6 mm.

The type is the only specimen. This species is assigned to *Triphora* in the wide sense. Definitions of the genus given by various authors do not entirely agree. Cossmann (*Essais*, livr. 7, p. 164, 1906), for instance, states that the coiling is always dextral, and the present species fits well his diagnosis, which is based on specimens of *T. plicatus* Desh. (Eocene), which Cossman states is the type-species. Woodring (*Miocene Molluscs from Bowden, Jamaica*, part 2, p. 328, 1928) quotes *Triphora gemmatum* Blainville as genotype by monotypy and states in his diagnosis that the shells are sinistral. Apart from this the species just described accords well with his diagnosis. Grant and Gale (*Pliocene and Pleistocene Mollusca of California*, p. 766, 1931) state that the shells are sinistral, but make no reference to the feature of the aperture.

The present record marks the advent of the genus *Triphora* into New Zealand faunal lists. Suter has recorded a number of Recent forms under *Triphora*, but Finlay (*Trans. N.Z. Inst.*, vol. 57, p. 384, 1926) has noted their divergence from that genus and has provided several new generic names to cover the series.

Maoricolpus sp.

The only turritellid listed by Marshall is *Turritella semiconcava* Suter. So far as the writer knows no form answering to this has since been collected. There are, however, the body-whorls of two large shells that do not answer to the description of *semiconcava*; and as well a number of apices of a *Maoricolpus*. It is likely that the form listed as *semiconcava* from Pakaurangi Point is a *Maoricolpus*. Better material is required before the specific identification of the present specimens can be decided.

Pareora striolata (Hutton).

About 150 specimens have been collected. There is no record of this, however, in the original lists. The Pakaurangi shells are all stouter than those from White Rock River, the type-locality. But as there is considerable variation amongst individuals from the latter locality, both as regards attenuation and sculpture, consideration of the status of the shells from Pakaurangi Point is left over until they can be examined in conjunction with shells from other localities.

Mathilda n.sp.

There are four apical fragments of a shell with the heterostrophe protoconch and sculpture of *Mathilda*. The arrangement of spiral ornamentation is suggestive of that of *Promathilda amoena* (Desh.), but the shell is apparently not so attenuate. In general form and attenuation the adult of this New Zealand species probably resembles *M. quadricarinata* (Brocchi). There are rude axial corrugations and thin axial lamellae here and there, but the spiral sculpturing is always predominant. The heavy keel is rather nodulated where crossed by the axials.

Ellatrivia kaiparaensis n.sp. (Figs. 26, 28, 31).

Shell small, ovate, dorsum ribbed to summit, but ribs weaken along summit where those from either flank coalesce. Spire concealed, position located by a low swelling, which, however, is crossed by ribbing. Ribs separated by concave interstices, whose width is about three times that of ribs. Outer lip with 16 ribs, inner with 14. Now and again there is sporadic divarication of a rib, but this is unusual and not a feature as in *avellanoides* McCoy. One or two of the ribs do not reach as far as the inner lip, but the specimens to hand show that this is variable. Aperture widening below and curved to left above. Outer lip rounded, swollen above level of external surface of body-whorl, projecting beyond apex. Columella much as in *T. memorata* Finlay.

Height, 5.0 mm.; width (side to side), 3.6 mm.; width (dorso-ventral), 3.0 mm. (figured paratype).

Two specimens in good condition.

Archierato simulacrum n.sp. (Fig. 36)..

Somewhat similar to *A. accola* but smaller, with the body less convex, and outer lip quite straight. Spire scarcely projecting above posterior surface; aperture with its sides parallel; terminal ridge heavy; inner lip hollowed behind upper end of ridge, this depression continuing along parietal wall as a broad shallow fossula. Denticles on body-wall very weak, spaced widely, seen best towards posterior. Outer lip with four small sharp denticles posteriorly and one or two weak ones in front.

Height, 4.2 mm.; width, 2.8 mm.

The type is the only specimen.

Archierato zepyrolata n.sp. (Fig. 35).

Spire moderate, broad, heavy. Body-whorl swollen behind, convex, early and rapidly drawn in to axis; base excavated. Aperture fairly wide, its sides about parallel; anterior opening broad. Parietal wall excavated from posterior third downwards. Terminal ridge narrow but well differentiated. Fossula fairly broad, lightly excavated, extending almost to upper third of inner lip, its outer edge marked by a low ridge with indistinct denticles, which become obsolescent towards posterior end. Outer lip dentate.

Height, 3.5 mm.; width, 2.5 mm.

Two specimens collected.

Cyprærato cf. submorosa (Laws).

There is a single shell closely resembling *submorosa*, but with higher spire, narrower beak and somewhat different arrangement of plications on columella. In the event of another similar individual turning up this will no doubt require a separate name.

Charonia cf. clifdenensis Finlay.

Part of the body-whorl showing aperture and suture. Very close indeed to *clifdenensis*.

Anstrosassia zealta n.sp. (Fig. 62).

A very fine new species after the style of *maoria* Finlay, but notably different in a number of characters. Like *A. procera* Finlay it is tall-spined, but is much larger, has different tubercles, different shaped body, and less distinct spirals. It has a much taller and narrower spire than *maoria*, very much stronger and more pointed tubercles, and lacks the lower of the two rows of tubercles on the body; and the suture is further below periphery so that the spire is more stepped. The spirals are also finer and the growth-striae are elevated into very fine threads. The aperture is more elongately oval in an antero-posterior direction, and there are seven denticles within outer lip. Anterior portion of inner lip not so excavated, and posterior not so nearly horizontal as that of *maoria*. The anterior canal trends to the left, that of *maoria* being almost vertical when shell is viewed ventrally. The anterior tuberculate cord of *maoria* is represented in the n.sp. by a row of granules larger than those on the spiral cords, but there is no angulation along the line on which these granules are set. No spirals on base are differentiated into heavy cords, but all are fine and threadlike. Base of inner lip

with one horizontal plait and several smaller below. There are five tubercles between varices, which are two-thirds of a whorl apart; tubercles decreasing in strength towards next later varix. The protoconch is similar to that of *maoria*.

Height, 53.5 mm.; width (estimated), 30 mm.

***Oniscidia* cf. *finlayi* Laws.**

There is the body-whorl of a shell resembling *O. finlayi*, a fossil from Clifden, Southland. The specimen is not adult and the posterior part of the inner lip is badly damaged, as also is the outer lip.

***Cirsotrema firmatum* n.sp. (Fig. 46).**

This species is distinguishable from *C. lyratum*, to which it is nearly allied, by the broad, heavy, close axials with very narrow interspaces. There are 12 axials on the body-whorl and these are disposed more obliquely than those of *lyratum*; the last whorl also bears three heavy varices, the last at outer lip and the others in turn at about a quarter whorl back. There are six primary spiral cords on the body-whorl (about 8 on *lyratum*) excluding the heavier one around basal disc, most of which is heavily covered by the flattened lower ends of the twisted and converging axials. The aperture is rather narrower from side to side than that of *lyratum*, its rim strongly thickened, there being a thick pad of callus on parietal wall. The plane of the peristome is set more oblique to the axis of the shell than is that of *lyratum*.

Height (estimated), 29.0 mm.; width, 11.5 mm.

***Turriscula kauparaensis* n.sp. (Fig. 72).**

Shell small, considerably attenuate, whorls convex, sutures distinct. Protoconch missing. Axial ribs thin, sharply elevated, distant, ten in number on last whorl of bigger fragment, some of them a little antecurrent to suture above. Spiral sculpture very faint, seen in interstices and surmounting axials; the sharp peripheral keel is seen as a margin just above suture. The axial ribs end against this keel. The rather flattened base carries a strong keel around its outer edge; and there are two weaker ones inside this. Aperture broken. Columella vertical, short.

Height (estimated), 18.0 mm.; width (estimated), 2.0 mm.

T. marginata (Hutton) is larger and has fewer (eight) axials per whorl. The peripheral keel is not as strong in the new species and the spiral sculpture is much better developed. *Marginata* has the whorls flatter, whereas in *kauparaensis* they are quite strongly convex.

***Pliciscala* n.sp.**

There are three fragments, one of them of the last three whorls of a small shell and two apical pieces with the protoconchs intact. These conform very well indeed with Cossmann's description of the genus (*Essais de Paléoconchologie Comparée*, no. 9, p. 83, 1912); the larger shell bears a striking resemblance to his figure (*loc. cit.*, pl. 6, fig. 25) of *Pliciscala macilentata* de Boury.

The protoconch is polygyrate, smooth and sharply pointed. The axial ribs are narrow, distinct, though not greatly elevated, and there are light varices present. Spiral sculpture is distinct under the hand-lens; the microscope shows the spirals to be strongly incised. They are about 12 per whorl, broad and separated by very narrow grooves bearing perforations.

Murdochella tricineta (Marshall).

1918. *Epitonium tricineta* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 263, pl. 19, figs. 8, 12.

1930. *Cirsotrema tricineta* (Marshall), Finlay, *Trans. N.Z. Inst.*, vol. 61, p. 233.

Finlay (*Trans. N.Z. Inst.*, vol. 61, p. 233, 1930) has tentatively referred this shell to *Cirsotrema*, but examination of the specimen recently obtained shows that it has little in common with that genus. It is reminiscent of *Clathroscala* de Boury, judging by the figures of several species given by Cossmann (*Essais*, livr. 9, 1912); but Cossmann makes no reference to embryonic characters. In the meantime the writer prefers to locate *tricinctum* in *Murdochella*. Finlay on account of its relationship with *M. superlata* Finlay, which, however, is doubtfully a *Murdochella*. *Tricineta* agrees with *superlata* in embryonic characters, general build, and pattern of sculpture, though the basal keel is not so heavy; and the axials, though thin, are not elevated into vertical lamellae like those of *superlata*. *M. alacer* Finlay and *M. tertia* Finlay along with *M. laevifoliata* (Murdoch and Suter), the genotype, form a series apart from *tricincta* and *superlata*, and are characterised by rather heavier embryo, lack of fenestrated sculpture, and presence of fine, close, very numerous axial foliations in place of definite, distant axial ribs.

The "*Epitonium trilineatum* n.sp." of Marshall's list (p. 273) no doubt is meant to be *Epitonium tricineta*, which is described on p. 263 of Marshall's paper.

Chemnitzia sp.

A specimen with the protoconch and upper whorls of spire only. The protoconch is coiled in a helicoid spiral, so that the shell represents a species of Group A, as defined by the writer in a previous paper (*Trans. Roy. Soc. N.Z.*, vol. 67, p. 49, 1937).

Pyrgolampros pakaurangiensis n.sp.

This shell has the typical *Pyrgolampros* build of whorl and the gross sculpture of that genus. Spiral sculpture is not evident, but the fine scratches typical of the genus are frequently only visible on the later whorls, which are damaged in the only specimen available. The protoconch is of very low helicoid type, and is broad and heavy, its nucleus considerably immersed. These characters at once distinguish the species from the Awamoan *semilaevigata*, its nearest relative, which it resembles closely. The outline is faintly convex; the whorls faintly sulcate at about their middle, and the axials weakly defined and broader than the interstices, which are almost linear. There is a faint swelling on the columella.

Height (estimated), 4.0 mm.; width, 1.3 mm.

Separable from *semilaevigata*, the only species with which it is necessary to compare it, by more slender habit, weaker axials, sulcate whorls and heavier protoconch, the nucleus of which is more immersed.

Finlayola angulifera Laws.

1937. *Finlayola angulifera* Laws. *Trans. Roy. Soc. N.Z.*, vol. 67, p. 312, pl. 44, fig. 18.

A single shell matches well this species from Clifden, Southland. The protoconch is more upright. Otherwise the shells from these two localities bear a striking resemblance.

Eulimella komitica n.sp. (Fig. 80).

Shell quite small, outlines straight, suture distinct, whorls flattish above, slightly overhanging suture below. Protoconch small, coiled in a low helicoid spiral, its lower edge tangent to suture below. Whorls a good deal broader than high. Body-whorl sharply rounded over periphery, flattish above, lightly rounded over base. Columella heavy, straight, vertical. Aperture sub-quadrate, but outer lip is broken back in all specimens.

Height, 2.0 mm.; width, 0.7 mm.

Seven specimens collected. *E. cori* is larger, has heavier and larger protoconch, whorls higher between sutures, and the suture not so well defined.

Eulimella parlimbata n.sp. (Fig. 70).

Shell of moderate size, outlines convex over early whorls, straight below that. Protoconch heterostrophic, coiled in a low helicoid spiral, nucleus with its lower edge tangent to suture below. Upper whorls of spire convex, later ones flat; suture distinct; early whorls a little shouldered high up at suture. Body-whorl long, over one-third height of shell; flat behind, broadly and evenly rounded over periphery; base convex. Columella thin, straight, oblique downwards to left. Aperture sub-quadrate; outer lip broken.

Height, 4.8 mm.; width, 1.6 mm.

The type is the only specimen. Very like *E. limbata* Suter. The body, however, is relatively higher, the whorls are higher in relation to width, and the sutures not so distinct. *Limbata* of the same height as *parlimbata* consist of 7 whorls as against 6 in the fossil.

Eulimella imitator n.sp. (Fig. 71).

This species combines the adult shell characters of *Terelimella* with the protoconch of *Eulimella*. Were it not for the embryo one would have no hesitation in placing it in *Terelimella*. The habit is acicular, the protoconch large when compared with the first few shell-whorls, and very exsert. It is coiled in a very low helicoid spiral, the lateral nucleus very small and quite clear of suture. The whorls are flat above and rather bulging below, thus tending to overhang suture. Pillar thin, arcuate, set vertically, with a tiny swelling well inside aperture. Aperture pyriform, angled behind and rather broadly rounded in front.

Height, 3.5 mm.; width, 0.8 mm.

Three specimens were collected.

Graphis neozelanica n.sp. (Fig. 76).

Shell very small, elongate-conic, axially ribbed, whorls strongly convex with a sloping shoulder above; suture well impressed. The protoconch is as described by Cossmann for *Graphis*, rather bulbous, few-whorled. Axials distinct, thin, sharply elevated, about three times their own width apart, straight below, antecurrent to suture above. On body-whorl axials evanesce quickly at about periphery. Base exceedingly finely spirally striated, as also is the surface of the last few whorls. Aperture broadly ovate; outer lip broken away; columella thin, faintly arcuate, set vertically.

Height, 2.5 mm.; width, 0.7 mm.

One specimen collected. This species has a strong resemblance to *Graphis gallica* de Boury, figured by Cossmann (*Essais de Paléoconchologie Comparée*, no. 9, pl. 6, figs. 26, 27, 1912).

Odostomia n.sp.

There are three specimens none of which is sufficiently well preserved for accurate discrimination.

Balcis badenia n.sp. (Fig. 12).

Shell small, shining, outlines straight, sutures very indistinct, whorls flat. Height of body not much less than half that of shell. Apex conical, of about three volutions rapidly increasing in width and convex in outline. Body-whorl flattish above, convex over periphery lightly convex on base. Aperture Rissoid in outline, but there is no anterior notch. Columella short, thick, arcuate. Inner lip lightly callused. Outer and basal lips very heavily and broadly thickened. Outer lip practically straight, except for a very slight recession towards suture; ascending at an appreciable angle from anterior. Outer lip notably effuse. Sculpture absent.

Height, 2.8 mm.; width, 1.2 mm.

About 100 specimens collected. The thickening of apertural rim recalls *Badenia* Finlay.

Balcis waikomitica n.sp. (Fig. 14).

Shell of moderate size, axis slightly curved, outlines perfectly smooth, sutures hardly visible. Apex sharply pointed, terminal volutions minute. Height of body-whorl about one-third that of shell. Aperture narrowly ovate, sharply angled behind and narrowly rounded in front. Columella thin, faintly arcuate, set vertically. Inner lip lightly callused. Outer lip thin, sharp; broadly and shallowly sinused above, convex below.

Height, 6.3 mm.; width, 1.8 mm.

Several specimens collected. A shell from Clifden, Southland (band 6C) is quite indistinguishable from those from the Pakaurangi Point beds. *M. tutamoensis* Marwick has the sutures better shown and is not so slender nor so much sharpened posteriorly. *Treadwelli* Hutton, also a curved form, has the protoconch globose and the outer lip almost straight.

Balcis kaiparaensis n.sp. (Fig. 73).

Shell small, elongate, outlines straight, though some individuals show a tendency to slight curvature of axis. Edge of spire quite

even in profile, sutures very indistinct, whorls quite flat. Apex conical, of about three lightly convex volutions regularly increasing in width, the tip sharp and pointed. Body sub-angled at periphery, flat above periphery, lightly convex on base. Columella fairly long, thin, slightly arcuate, set vertically. Inner lip very thinly callused. Outer lip rounded over in fully adult shells, not thickened, broadly sinused behind and convex in front. Aperture ovate-rotund. Height of body-whorl less than one-third that of shell.

Height, 4.9 mm.; width, 1.4 mm.

About 100 specimens collected. *Kaiparaensis* differs from *waihaoensis* Allan in that the latter is a much larger and more heavily built species, stouter in habit and with the outer lip straighter above and less convex below than that of the Pakaurangi Point shell. *Otaioensis* Laws is also a heavier, stouter species, with blunter and heavier apex and body more angled at periphery. *Christyi* Marwick is somewhat similar in build, but is much larger and has the protoconch depressed and bulbous. *Vegrandis* Murdoch and Suter has protoconch of fewer volutions, whorls not so flat, and is a larger species.

***Uromitra neozelanica* n.sp. (Fig. 43).**

There are four shells that agree with Woodring's description of *Uromitra belardii* (*Mioc. Moll. from Bowden, Jamaica*, pt. 2, Gastropods, p. 246, 1928) and that show close alliance with such forms as *U. callipicta* and *U. uncida* (*loc. cit.*, p. 248, pl. 14, fig. 20; and p. 248, pl. 15, fig. 1, respectively). None, however, have the protoconch preserved. Height of spire $1\frac{1}{2}$ times that of aperture plus canal. Whorls seven, lightly and evenly convex, slopingly shouldered; suture distinct. Whole surface sculptured by axial costae and spiral cinguli, the former the more strongly developed, although the latter are strong enough to cause cancellation of sculpture. Number of axials varies a good deal; holotype with 14 axials on penultimate whorl, a paratype with 25. There is axial acceleration over last half of body-whorl. Spirals broad, low, flat, their interstices almost linear, 7 to 8 in number on penultimate whorl, surmounting axials and causing very slight nodulation. Beak with certain spirals outstanding. Pillar with four folds decreasing in strength anteriorly; the posterior one horizontal and the others becoming more oblique in order towards anterior. Parietal callus present. Outer lip internally liriate throughout entire length, the lirae being set a little distance from edge of lip. Anterior canal fairly long, twisted and practically no notch.

Height, 19.0 mm.; width, 6.0 mm.

Four specimens collected.

***Verconella parans* Finlay.**

1930. *Trans. N.Z. Inst.*, vol. 61, p. 70, pl. 3, figs. 17, 27.

Two shells of this species have been collected. The protoconch is smaller than that of *parans* from Clifden and consists of two volutions, and the early post-embryonic whorls of Clifden specimens are a little higher in relation to width than those of Pakaurangi shells. Otherwise there is no difference. The shells are not fully adult, and the question as to whether they are to be regarded as distinct must be left over in the meantime.

Hima (Mirua) separabilis n.sp. (Fig. 52).

Comparison of Pakaurangi Point shells with abundant topotypes shows a number of constant differences that warrant recognition of a separate species. *Socialis* is more heavily and more rudely sculptured and has not the thin, regular axials of *separabilis*. The former has 9 axials on the penultimate whorl and the latter 16. The spiral sculpture also is much coarser and the spirals fewer in number in the Awamoan species, the interstices between spirals about equal to width of ribs, whereas the new species has the interstices linear. The spirals of *socialis* nodulate the axials perceptibly, a feature that is not obvious in *separabilis*. *Separabilis* has 11 to 12 spirals on penultimate whorl, *socialis* but 6. There are also embryonic differences. In both the protoconch is conical, polygyrate and pointed, but *socialis* has an embryo of about three volutions and *separabilis* one of four turns. In the latter the protoconch is larger and noticeably wider across the base. There is an important contrast in the incidence of adult sculpture; *socialis* has spirals (about 4) developing first and the axials developing later, whereas it is the reverse in the case of *separabilis*. Also the early axials of *separabilis* are strongly arcuate (convex backwards), those of *socialis* straight.

Height, 5.5 mm.; width, 3.1 mm.

Twelve specimens collected.

Terefundus n.sp. aff. *quadricinctus* (Suter).

There is one immature shell. The protoconch is finely spirally striated. It is expected that better material will yet become available.

Merica kaiparaensis n.sp. (Fig. 50).

Close to *M. pukeuriensis* Finlay. Finlay's description of the protoconch of his species fits that of the Kaipara one, except that there are three instead of the $3\frac{1}{2}$ volutions of *pukeuriensis*. The spiral on shoulder on border of the deep channel around suture heavily tuberculates the axials, as does that on angle of whorls. There is no intercalation of weak spirals as in *pukeuriensis*, and the spirals of that species are more strongly developed. On the body-whorl there are 13 low, thin, spaced spiral threads with two very weak ones on the shoulder between the two heavy cords. Penultimate whorl has no spiral threads on shoulder. Axials much as those of *pukeuriensis*, except that there are 13 instead of 16 on body-whorl. In the features of aperture there is little difference between the two forms. The basal fasciole of *kaiparaensis* is rather more swollen and the beak not so pointed.

Height, 10.0 mm.; width, 6.0 mm.

The type is the only specimen.

Zemitrella inconspicua (Marshall).

1918. *Mitrella inconspicua* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 266, pl. 19, figs. 9, 13.

The writer has 24 specimens. The protoconch contrasts with that of *choava* in that it is very tiny and the apex very sharply pointed.

Bathytoma bartrumi n.sp. (Fig. 25).

Shell of moderate size, outline of spire straight, its height a little greater than that of aperture plus canal. Whorls keeled at

about anterior fourth on mid-spire, almost at suture on early post-embryonic volutions, and a little below middle on last one or two. Protoconch of several volutions, conical. The carina bears strongly elevated nodules, closely spaced on early whorls, but widely separated on later whorls; 14 nodules on penultimate-whorl. Whole adult surface ornamented with spiral sculpture, the spirals on shoulder being fine threads, those below keel and on base coarser and distinctly granular, the granules set close together as in *haasti*. There are three or four fine, wavy spiral threads between the cords on the body.

Height, 42.0 mm.; width, 18.5 mm.

Several specimens collected. This species is readily separated from both *haasti* and *mitchelisoni* by the straight spire-outline and rather prickly, stronger, distant nodules.

***Bathytoma finlayi* n.sp. (Fig. 23).**

This species has the convex spire-outline of *haasti* and the prickly nodules of *bartrumi*. The situation of the keel on whorls is the same as that described for *bartrumi*. The nodules, though sharply elevated are more numerous than those of *bartrumi*, 22 on penultimate whorl. The spirals on the base are much stronger, fewer in number, and tend to be nodulated rather than granulated. Only two interstitial spirals are present on base between the cords. In this respect the species is akin to *haasti*.

Height, 36.0 mm.; width, 16.0 mm.

Locality: Clifden, Southland, bed C on left side of Waiau River.

***Comitas kaupara* n.sp. (Fig. 44).**

Twelve individuals have been obtained and these consistently differ from *fusiformis* in a number of characters. The adult *kaupara* attains nothing like the size of adult *fusiformis*, and is of more slender habit; the axials are more nodulous and give the whorl an angulated profile, the profile of an axial on *fusiformis* being convex. The spiral cords on and below the angle of whorls are coarser than those of *fusiformis*, and these spirals thicken on surmounting the axials. The early post-embryonic whorls have only two spiral cords, on later whorls others appear below them; those on the keel, however, always remain the strongest. The shoulder is smooth and has only weak spiral, almost linear, grooves on it. The number of axials is approximately the same for both species. The protoconch of *kaupara* is closely similar to that of *fusiformis*.

Height (estimated), 25.0 mm.; width, 8.0 mm.

"*Guraleus*" *axialis* (Marshall).

1918. *Mangilia axialis* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 269, pl. 19, figs. 10, 14.

Through the courtesy of Mr. J. Grant, honorary conchologist, Wanganui Museum, the writer has been enabled to examine the material on which this species was founded. There are three shells one of which is complete. The shell figured by Marshall can be

identified among the material, and is not the complete specimen, but has the outer lip considerably broken, and as no other type-designation was made, this shell must be taken as the lectotype.

The embryo is polygyrate, conical, and pointed, its whorls lightly convex and the sutures ill-defined. Marshall's description of the axial ribs as "rounded" is hardly sufficient; they are spaced at intervals of about three times their own width, and are narrow, rounded over crests, but somewhat pinched up, their flanks being concave. The whole surface has fine spiral threads (not "lines"), weaker on the shoulder of whorls. Axials on body flexuous, antecurrent to suture (on shoulder). Outer lip thickened by last rib, convex from the side. There is a low denticle on parietal wall at posterior end of aperture. The spirals towards beak are coarser than those elsewhere. Whorls shouldered above middle, the shoulder lightly concave; convex below.

There are two topotypes in the writer's collection.

***Inquisitor komiticus* n.sp.**

Shell fairly small, attenuate, resembling very closely *I. awamoensis* (Suter). Protoconch pointed and polygyrate, closely similar to that of *awamoensis*. *Wahoraensis* has the keel lower on whorls and the shoulder consequently wider; the axials are sharper and it has fewer and heavier spirals than *komiticus*. The swollen sub-sutural border of *awamoensis* has two low, indistinct threads on it, that of *komiticus* carries three distinctly incised ones. The shoulder of the former has two very distinct, widely separated spiral threadlets, while *komiticus* shows eight distinct, close threads on the shoulder. Below the angulation of whorl there are 7 to 8 strong, thick spirals (frequently with interstitial threadlets) on *komiticus*, whereas *awamoensis* has only 5 or 6, which are widely spaced, thinner, and each pair with an interstitial threadlet.

Height (estimated), 22.0 mm.; width, 6.0 mm.

Four specimens collected. In the Awamoan beds at Pukeuri, Awamo Creek and elsewhere, there are shells agreeing with *awamoensis* in almost every respect except that the apex is paucispiral and rather globose, that of *awamoensis* being polygyrate and pointed.

This species will be figured in paper No. 2 of this series.

***Zemacies climacota* (Suter).**

1917. *Surcula climacota* Suter, *N.Z. Geol. Surv. Pal. Bull.*, no. 5, p. 50, pl. 9, fig. 15.

Seven individuals have been collected, two of them complete. The protoconch is seen to be closely similar to that of *elatior* Finlay, the genotype. *Climacota* may be distinguished from *ordinaria*, associated with it in the same beds, by its smaller adult size and more numerous, sharper and more closely spaced nodules on keel; the axial prolongation of nodules downwards, typical of *climacota*, is not present in *ordinaria*; also the spirals on the body are more definite and regular, and have not the weaker interstitial riblet typically developed in *ordinaria*.

***Daphnella kaiparica* n.sp. (Fig. 22).**

Shell small, whorls strongly convex, axially costate, ornamented also with spiral threads. Height of spire one and one-third times that of aperture. Protoconch polygyrate (four turns), conical, nucleus minute, volutions distinctly convex, its sutures distinct; it is sculptured over anterior two-thirds of all its turns by a criss-cross pattern of excessively fine threads, each series running obliquely to lower suture; the upper third of each embryonic volution is ornamented by thin hairlike vertical axials. Adult whorls retreat to suture quickly above, the shoulder narrow and faintly excavated. Axial ribs spaced widely, thin, rounded, sharply elevated, extending entirely across whorls, those on body (11 in number) dying out low down. Spiral threads (about 8 on penultimate whorl) fine, thin, spaced, distinct, weak on shoulder; present on and between axials, rather thicker on surmounting the ribs forming slight nodules; interstitial threadlets present. Beak with six strong nodulous spirals. Very fine axial growth-threads are present on shoulder. Body-whorl early and rapidly drawn in to axis of shell; beak long; inner lip smooth, sunken on parietal wall; a light denticular swelling on parietal wall near posterior angle of aperture. Sutural sinus shallow.

Height, 4.7 mm.; width, 2.1 mm.

A single specimen collected.

***Daphnella clifdenica* n.sp. (Fig. 19).**

Shell small, whorls convex, suture very distinct, height of spire $1\frac{1}{2}$ times that of aperture plus canal. Protoconch large, polygyrate ($4\frac{1}{2}$ turns), conical, nucleus minute, volutions very convex, sutures strongly cut in; sculpture of embryo of same pattern as that of *kaiparica* n.sp., only the ridges are very much more delicate and more perfectly executed. Adult whorls not shouldered, convex throughout; notably high compared with width. Axial ribs widely spaced, about four times their own width apart, 7 in number on last whorl, narrow, convex, vertical, straight, extending low down on base of body-whorl. Spirals 7 or 8 primary ones on penultimate whorl; interstitial secondary riblets universally present; spirals surmounting axials, but causing no nodulation. Beak with 6 or 7 spirals, but not as strong as those of *kaiparica*. Aperture moderately wide, roundly angled behind; outer lip chipped away in parts, curving in to suture above, then descending almost straight for half its length, thereafter widely rounded to merge into basal lip; inner lip smooth, sunken on parietal wall. Body-whorl contracting early and rapidly. Sutural sinus shallow.

Height, 6.45 mm.; width, 2.5 mm.

The type is the only specimen.

Locality: Clifden, Southland, roadcutting behind racecourse.

Distinguished from *kaiparica* by larger, more convex, and more finely sculptured embryo; more widely spaced axials; less prickly sculpture. Not unlike an Australian fossil from Altona Bay. Both have the protoconch closely similar, and they are much alike in sculpture.

***Surcula latiaxialis* Marshall.**

1918. *Surcula latiaxialis* Marshall, *Trans. N.Z. Inst.*, vol. 50, p. 267, pl. 20, figs. 3, 3a.

A single specimen with the upper whorls lost has been collected. The characters of the adult whorls are those of *Comitas* Finlay.

***Clavus kaupara* n.sp. (Fig. 47).**

Shell small, elevated, height of spire twice that of body; whorls strongly shouldered over upper third, the shoulder distinctly excavated and unsculptured. Axial sculpture consists of strong, sharply pinched up ribs extending over anterior two-thirds of whorl, and pointed at posterior extremities. Axials 11 in number on penultimate whorl. Protoconch conical, polygyrate, of about $3\frac{1}{2}$ lightly convex, smooth volutions, its summit sharply pointed, nucleus minute. Spiral sculpture limited to about ten weak threads near beak, which is twisted somewhat to the right. Aperture filled with matrix and outer lip broken back; but part of the posterior notch and the pad of callus at posterior extremity of inner lip can be seen.

Height, 7.0 mm.; width, 2.3 mm.

This species is congeneric with *Surcula nitens* Marshall from the same beds. *Nitens* has heavier, more rounded and fewer axials per whorl (about 10), the shoulder is not concave, and the axials are not muricated at their posterior extremities. Though these species show affinity with *Clavus* revision of the Neozelanic Turridae may warrant their recognition as a group apart from *Clavus*. Other species occurring at a number of South Island localities await description.

***Nepotilla bartrumi* n.sp. (Fig. 45).**

Shell minute; spire staged, a little higher than aperture plus canal; whorls strongly, flatly shouldered, almost tabulated. Protoconch of $1\frac{1}{2}$ spirally lirate volutions. Whorls biangled, flatly shouldered above, quickly drawn in to suture below. Each whorl has two strong spiral cords, one at edge of shoulder, and the other at about middle; between the latter and suture there is a third but very weak spiral. On the body the anterior of the two strong cords is on the periphery, and there are three weak ones on base. The axials (10 to 12 on body-whorl) are thin, narrow, sharply elevated, and very conspicuous, somewhat muricated at summits by the cord around edge of shoulder, and also nodulated where crossed by the more anterior strong cord. On body-whorl axials extend well down on to base. The sculpture tends to be reticulated, but the spirals are not as pronounced as the axials. Aperture typical; sinus deep, situated immediately below suture; canal short, open.

Height, 1.55 mm.; width, 1.0 mm.

Seven specimens collected. This is the second Neozelanic species of the genus, and the first fossil one, to be described, *N. finlayi* Powell being a Recent shell taken in deep water off Three Kings Islands.

***Acteon procratericulatus* n.sp. (Fig. 64).**

This shell is very close to the Recent *A. cratericulatus* Hedley. However, it has the spirals quite regular and all of equal width; the interspaces are always distinctly narrower than the spiral ribs. The

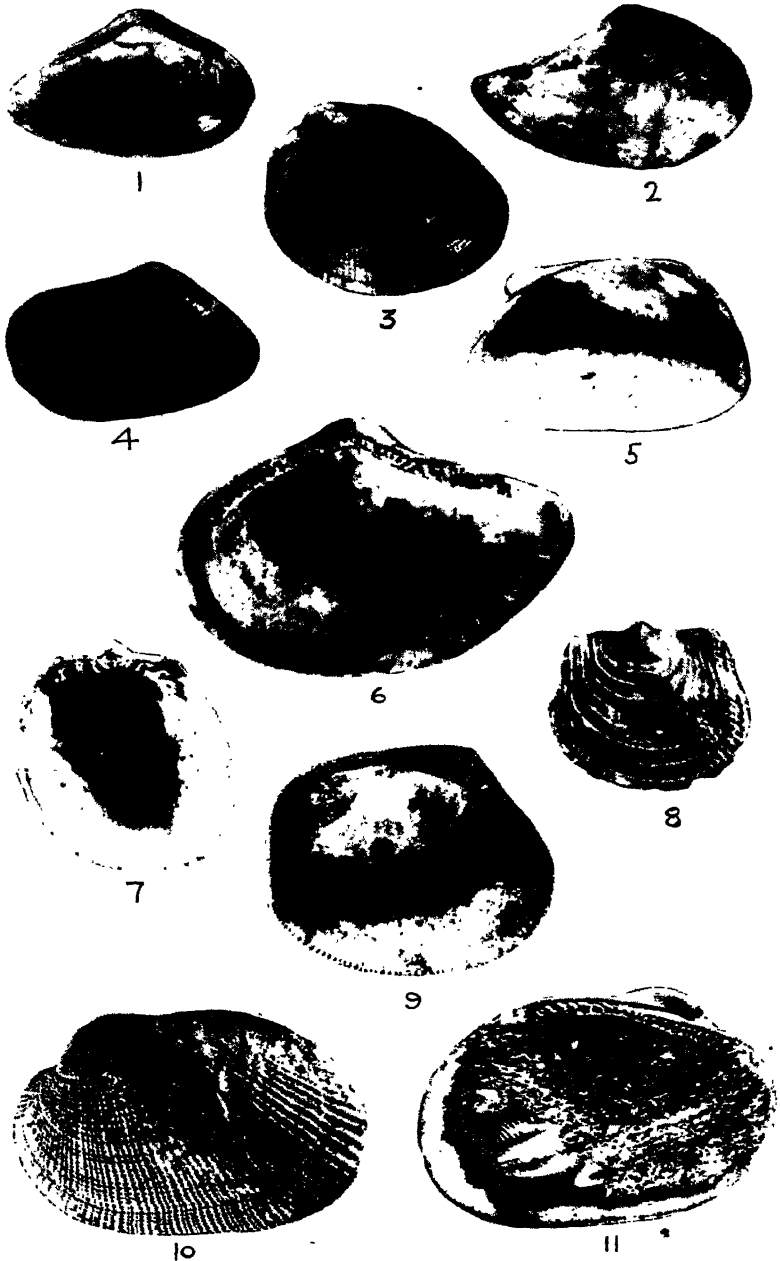


FIG. 1—*Nuculana (Jupiteria) vadosa* n.sp.; holotype, $\times 21.5$. FIG. 2—*Nuculana (Succella) duplicarina* n.sp.; holotype, $\times 5.5$. FIG. 3—*Nucula otamatea* n.sp.; holotype, $\times 10.0$. FIG. 4—*Angulus (Peronidia) inflata* n.sp.; holotype, $\times 2.0$. FIG. 5—*Kidderia otamatea* n.sp.; holotype, $\times 21.5$. FIG. 6—*Nuculana (Jupiteria) parleachi* n.sp.; holotype, $\times 8$. FIG. 7—*Limopsis propeirralida* n.sp.; holotype, $\times 9.4$. FIG. 8—*Cyclopecten (Cyclochlampus) shepherdi* n.sp.; holotype, $\times 21.5$. FIG. 9—*Salaputium tinopalca* n.sp.; holotype, $\times 3.7$. FIGS. 10, 11—*Arca mundeformata* n.sp.; holotype, $\times 5.5$.

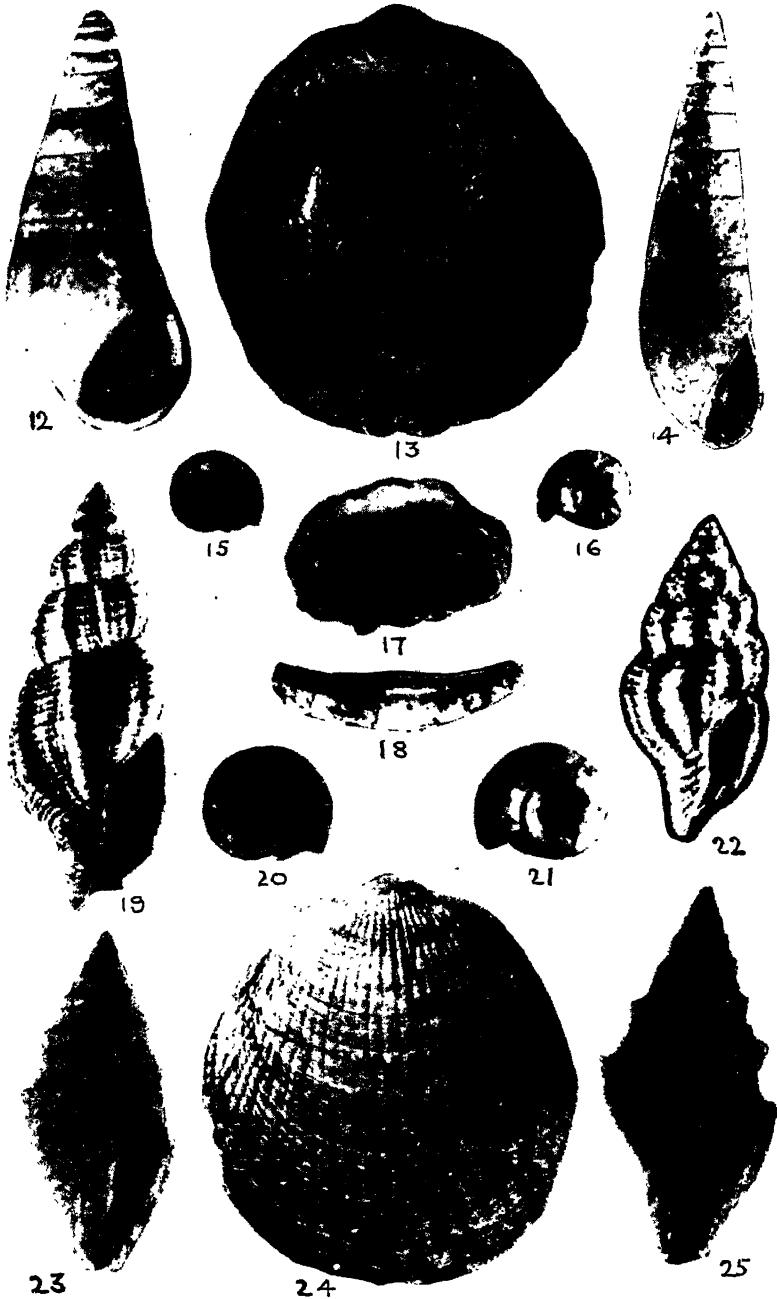


FIG. 12—*Balcis badenia* n.sp.; holotype, $\times 21.5$. FIGS. 13, 24—*Glycymeris* (*Grandarinea*) *finlayi* n.sp.; holotype, $\times 0.9$. FIG. 14—*Balcis waikamitica* n.sp.; holotype, $\times 10.0$. FIGS. 15, 16—*Orbitostella praetoreuma* n.sp.; holotype, $\times 21.5$. FIG. 17—*Cardita kauparaensis* n.sp.; holotype, $\times 3.3$. FIG. 18—*Cadulus zecaninus* n.sp.; holotype, $\times 10.0$. FIG. 19—*Daphnella clifdenica* n.sp.; holotype, $\times 10.0$. FIGS. 20, 21—*Orbitostella praeclinemosa* n.sp.; holotype, $\times 21.5$. FIG. 22—*Daphnella kauparica* n.sp.; holotype, $\times 10.0$. FIG. 23—*Bathytoma finlayi* n.sp.; holotype, $\times 1.3$. FIG. 25—*Bathytoma bartrumi* n.sp.; holotype, $\times 1.3$.



FIG. 26, 28—*Ellatrivia kaiparaensis* n.sp.; paratype, $\times 8.0$. FIG. 27—*Scaphander komiticeus* n.sp.; holotype, $\times 10.0$. FIGS. 29, 30—*Antisolarium tricarinatum* n.sp.; holotype, $\times 10.0$. FIG. 31—*Ellatrivia kaiparaensis* n.sp.; holotype, $\times 5.5$. FIG. 32—*Alys lacrimula* n.sp.; holotype, $\times 10.0$. FIG. 33—*Scaphander komiticeus* n.sp.; paratype, $\times 10.0$. FIG. 34—*Lissotesta alpha* n.sp.; holotype, $\times 21.5$. FIG. 35—*Archierato zephyrulata* n.sp.; holotype, $\times 10.0$. FIG. 36—*Archierato simulacrum* n.sp.; holotype, $\times 10.0$. FIG. 37—*Lissotesta beta* n.sp.; holotype, $\times 21.5$. FIG. 38—*Emarginula kaiparica* n.sp.; holotype, $\times 5.5$. FIG. 39—*Kaitoa recta* n.sp.; holotype, $\times 10.0$. FIG. 40—*Emarginula komitica* n.sp.; holotype, $\times 5.5$. FIG. 41—*Lodderia komitica* n.sp.; holotype, $\times 21.5$. FIG. 42—*Cylichnanta plana* n.sp.; holotype, $\times 10.0$.

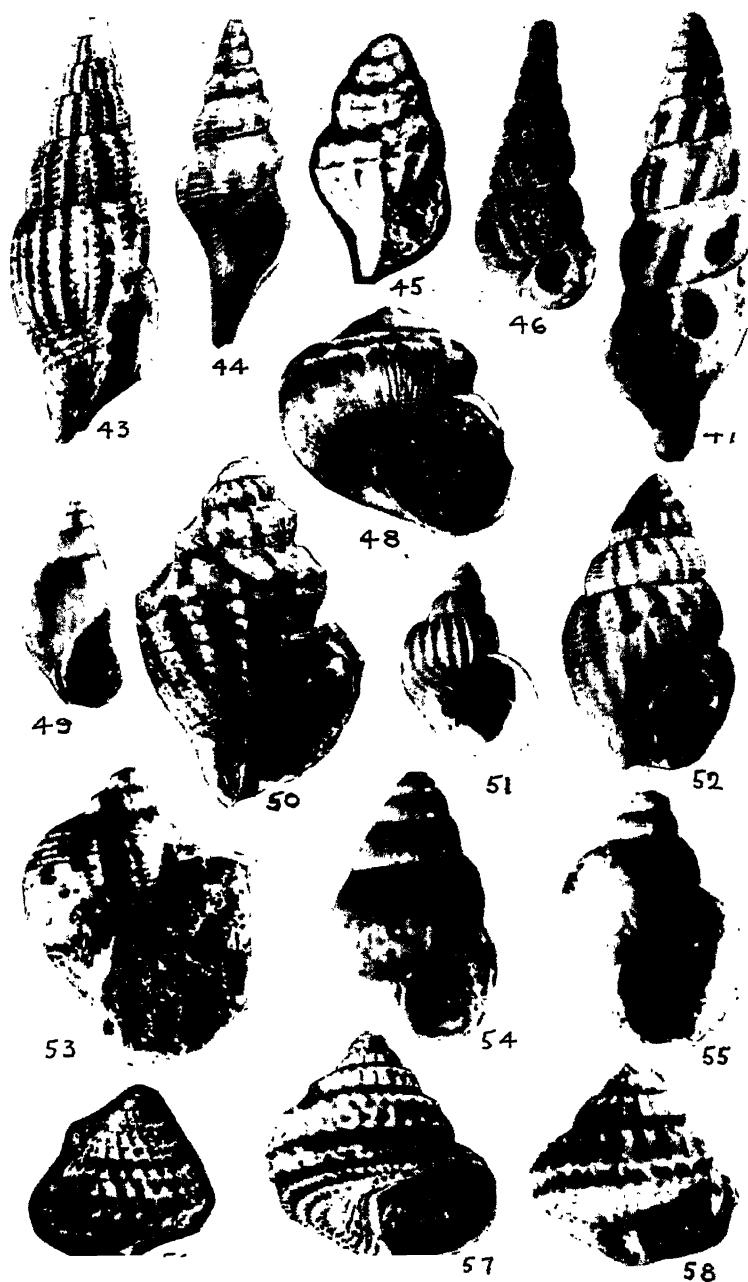


FIG. 43—*Uromitra neozelanica* n.sp.; holotype, $\times 3.4$. FIG. 44—*Comitas kaupara* n.sp.; holotype, $\times 2.1$. FIG. 45—*Nepotilla bartrumi* n.sp.; holotype, $\times 21.5$. FIG. 46—*Cirsiotrema firmatum* n.sp.; holotype, $\times 1.6$. FIG. 47—*Clavus kaupara* n.sp.; holotype, $\times 10.0$. FIG. 48—*Schizotrochus miocenica* n.sp.; holotype, $\times 21.5$. FIG. 49—*Zeradina aculeata* n.sp.; holotype, $\times 10.0$. FIG. 50—*Merica kauparaensis* n.sp.; holotype, $\times 5.5$. FIG. 51—*Zeradina* (*Naridista*) *jocelynae* n.subgen., n.sp.; holotype, $\times 21.5$. FIG. 52—*Hima* (*Mirua*) *separabilis* n.sp.; holotype, $\times 8.1$. FIGS. 53, 55—*Zeradina* (*Radnista*) *vicienneae* n.sp.; FIG. 53, holotype; FIG. 55 $\times 19.0$. FIG. 54—*Haurakia onerata* n.sp.; holotype, $\times 21.5$. FIG. 56—*Zetela parvumbilicata* n.sp.; holotype, $\times 21.5$. FIGS. 57, 58—*Zetela hutchinsoniana* n.sp.; holotype; FIG. 58 $\times 21.5$.

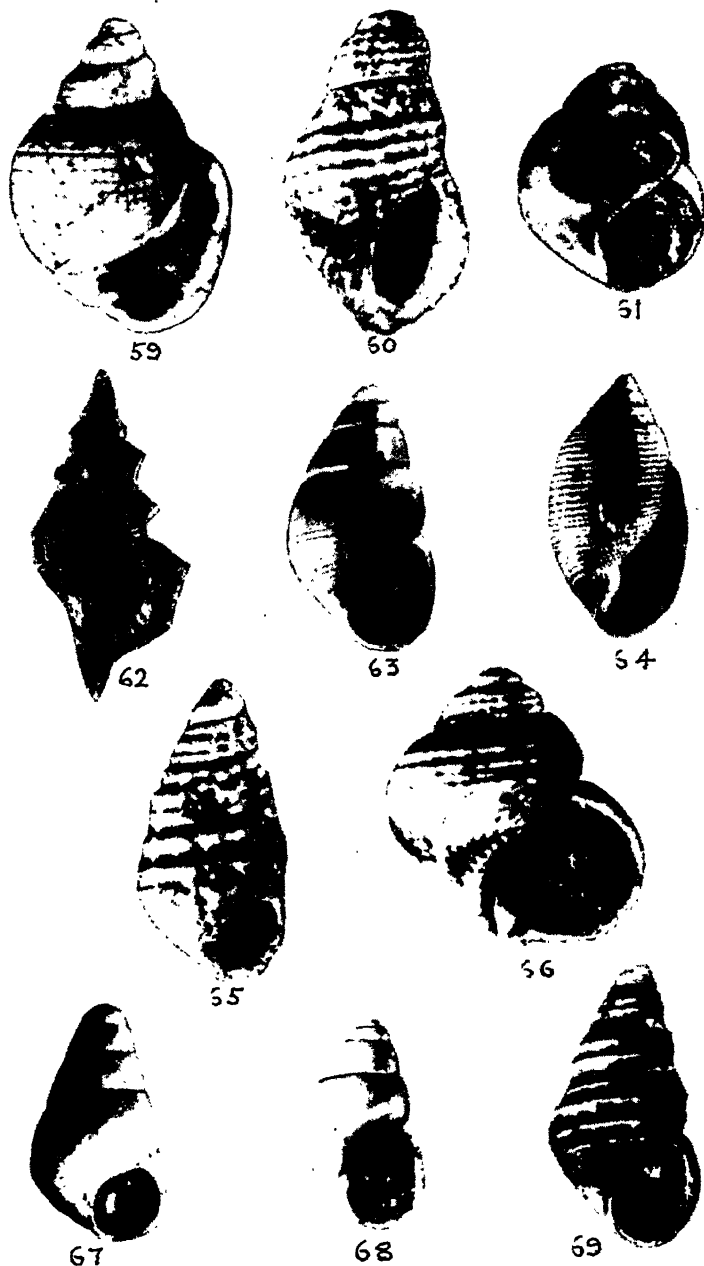


FIG. 59—*Ringicula zecorpulenta* n.sp.; holotype, $\times 21.5$. FIG. 60—*Leucotina granulocostata* n.sp.; holotype, $\times 16.0$. FIG. 61—*Dolichrossea atypica* n.sp.; holotype, $\times 21.5$. FIG. 62—*Austrosassia zeatta* n.sp.; holotype, $\times 0.9$. FIG. 63—*Haurakia sodalis* n.sp.; holotype, $\times 21.5$. FIG. 64—*Acteon procratericulatus* n.sp.; holotype, $\times 5.5$. FIG. 65—*Meretina saginata* n.sp.; holotype, $\times 21.5$. FIG. 66—*Crosseola sinemacula* n.sp.; holotype, $\times 21.5$. FIG. 67—*Dardanula praecursor* n.sp.; holotype, $\times 21.5$. FIG. 68—*Nozeba perpava* n.sp.; holotype, $\times 21.5$. FIG. 69—*Nobollira inflata* n.sp.; holotype,



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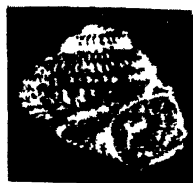
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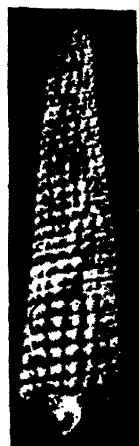
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FIG. 70—*Eulimella parlimbata* n.sp.; holotype, $\times 10.0$. FIG. 71—*Eulimella imitator* n.sp.; holotype, $\times 10.0$. FIG. 72—*Turriscula kauparaensis* n.sp.; holotype, $\times 10.0$. FIG. 73—*Balcais kauparaensis* n.sp.; holotype, $\times 10.0$. FIG. 74—*Scissurella condita* n.sp.; holotype, $\times 21.5$. FIG. 75—*Brookesena dupuicincta* n.sp.; holotype, $\times 21.5$. FIG. 76—*Graphis neozelanica* n.sp.; holotype, $\times 21.5$. FIG. 77—*Notosinister cespina* n.sp.; holotype, $\times 10.0$. FIG. 78—*Zetela awamoana* n.sp.; holotype, $\times 10.0$. FIG. 79—*Zaclys (Mioptila) simulator* n.sp.; holotype, $\times 10.0$. FIG. 80—*Eulimella komitica* n.sp.; paratype, $\times 19.5$. FIG. 81—*Zaclys (Mioptila) mucro* n.sp.; holotype, $\times 10.0$. FIG. 82—*Triphora neozelanica* n.sp.; holotype, $\times 10.0$.

reticulation of sculpture is very regular and not so open, but finer than that of *cratericulatus*. The spire of the fossil is shorter, its height only one-third that of shell and not nearer the half as in Hedley's species; further, the body is heaped up more posteriorly and is not so full below the periphery. The plait is distinctly heavier and the channel behind columella deeper and better differentiated.

Height, 7.5 mm.; width, 4.0 mm.

***Leucotina granulocostata* n.sp. (Fig. 60).**

This is a peculiar little shell, of unusually heavy build, rude sculpture, large flat embryo, and the plane containing the peristome set at an unusual inclination. Spire higher than aperture, whorls convex, not shouldered, last whorl descending quickly from suture, which is indistinct. Apex blunt, widely rounded over top; embryo smooth, of about one volution. Whorls four in number, heavily spirally ribbed; body with 10 spirals, 8 of them heavy and rudely fashioned, the anterior two fine and small. Spirals rather granulose. Axial sculpture not well developed, the fine axial threadlets typical of other species now replaced by low, wide, irregular, crude connections across spiral grooves. Aperture narrowly ovate, rim thick; narrowly rounded in front, angled behind; columella long, heavy, flattened below, junction with parietal wall very obtusely rounded. There is a small but distinct plait high up and well within aperture. Outer lip dentate.

Height, 3.0 mm.; width, 1.6 mm.

The type is the only specimen. Easily separable from the other tall-spined Aeteons such as *ambiguus*, *articulatus*, *ovalis*, and *praecursorius*.

***Ringicula zecorpulenta* n.sp. (Fig. 59).**

Shell very small, spire stepped, its height less than half that of body. Body-whorl extremely inflated. All adult whorls marked by clearly incised linear spiral grooves. On body there is a groove close below suture, then a broad flat zone without spiral ornamentation; anterior to this spiral grooves are again developed, the first few rather widely spaced, the remainder more closely spaced. Columella with two heavy plaits horizontally disposed, a third arising from body-wall above and further within aperture; inner lip heavily callused; outer lip very considerably thickened.

Height, 2.3 mm.; width, 1.5 mm.

Twenty-five specimens collected. *Torquata* Marwick differs from *zecorpulenta* in having the suture margined by a cord, spirals only on the body, and grooves pitted. *Castigata* Marwick is smaller, has the spire higher relative to height of shell, and the body not so full. Both *obesior* and *tutamoensis* have the spire much less conspicuous, not so stepped, and the body not so swollen.

***Scaphander komiticus* n.sp. (Figs. 27, 33).**

Shell small, almost regularly boat-shaped. Whole surface ornamented by regular, spaced, punctate spiral grooves, weaker and closer together around posterior. No constriction below posterior

end as in *S. hiulcus* and *S. scaphus*. Columella long, thin, gently arcuate, with a very light, narrow groove paralleling it on the outside. Inner lip barely callused. Outer lip regularly convex when viewed ventrally, and not drawn outwards as in *scaphus*, more like that of *hiulcus*, but not projecting above posterior end of shell. Separable from *hiulcus* also by the body swelling very much more into aperture posteriorly. In *scaphus* the aperture is more constricted behind and more effuse in front.

Height, 5.5 mm.; width, 3.0 mm. Corresponding dimensions of a paratype: 8.0, 4.5.

Seven specimens collected.

***Cylichnania plana* n.sp. (Fig. 42).**

Shell small, outline gently and evenly convex, narrowly umbilicate at posterior end. Much smaller than *C. bartrumi* and with a relatively narrower posterior end. The posterior extremity of aperture scarcely protrudes behind, whereas in *bartrumi* it is distinctly produced. Weak linear spiral grooves are developed towards the anterior end only. *Bartrumi* has the grooves not linear, more strongly incised, and present over whole surface of body. The features of aperture are similar in both species. *C. circumscripta* Marwick has two weak folds and is sculptured differently.

Height, 4.9 mm.; width, 2.1 mm.

Seven specimens collected.

***Kaitoa recta* n.sp. (Fig. 39).**

Shell small, outlines gently and evenly convex; spiral grooves developed towards anterior only, not punctate. Summit consists of a circular depression, its rim sharp. Apex visible at bottom of depression, at least in young specimens. Aperture narrow behind, widening considerably in front. Outer lip regularly convex when viewed ventrally. Inner lip very lightly convex over posterior third, then turning in rapidly towards columella. Columella smooth, long, thick, almost straight, tapering anteriorly, with thick outer edge bordering a narrow groove running back towards its insertion.

Height, 4.3 mm.; width, 2.0 mm.

Eight specimens collected. *K. islandica* Marwick has the columella arcuate, a differently shaped inner lip, and spirals over whole surface. *K. haroldi* Marwick is much larger and has the columella concave.

***Atys (Aliculastrum) lacrimula* n.sp. (Fig. 32).**

Shell small, spire involute, summit perforated, posterior of aperture produced and notched. Posterior end of shell much narrower than anterior. Aperture extending whole length of shell, widening in front. Basal lip broadly rounded; columella thick, a weak fold appearing internally; outer lip almost straight, twisted over behind and bearing a small fold near its insertion in apex. Body-whorl narrow behind, faintly concave towards posterior, expanding con-

siderably below, its outline broadly and gently rounded. Surface with low, vertical, fairly regular growth-plications and faint spiral grooves, more numerous and closely spaced towards each extremity, elsewhere extremely faint and wide apart, apparently easily worn off. A moderate umbilical groove borders left of columella.

Height, 4.0 mm.; width, 2.0 mm.

Twelve specimens collected. This shell bears a striking resemblance to *Volvulella dekayi* (Lea) figured by Cossmann (*Essais*, pl. 4, figs. 1, 2, 1895), on which species Cossmann based his diagnosis of *Volvulella*. It is also reminiscent in general build of *Retusa chipolana* Dall from the Chipola Oligocene (*Trans. Wag. Free Inst. Sc. Phil.*, vol. 3, pt. 6, pl. 59, fig. 9, 1903).

***Cadulus zecaninus* n.sp. (Fig. 18).**

Shell small, surface perfectly smooth, shining; lightly curved, notably swollen at middle; outer side of shell curved almost uniformly, though straightening a little below; inner side straight below, swollen at middle, concave above that. Aperture broken, but apparently broadly oval; posterior opening circular, edge thin.

Length, 3.9 mm.; diameter (greatest), 0.95 mm.

Four specimens collected. Probably the "*Cadulus delicatulus* Suter" of Marshall's list.

New Zealand Foraminifera: Key Species in Stratigraphy —No. 1.

By H. J. FINLAY, D.Sc.

[*Read before the Wellington Philosophical Society, October 11, 1938; received by the Editor, October 11, 1938; issued separately, March, 1939.*]

THIS is the first of what is hoped to be a series of papers on New Zealand Upper Cretaceous to Recent Foraminifera. Since ceasing work on mollusca five years ago I have been working at the faunas, range of species, and extent of useable variation met with in New Zealand in these smaller shells, and have withheld publication of any results until a general survey was possible for the whole area. Many hundreds of fully sorted and mounted type slides have by now been prepared as a basis, from all the horizons known here as yet, and from most variations in facies of each. Although an enormous amount of detailed work will always remain, enough is now accurately known regarding general conditions and the occurrence of certain important forms to warrant a start on its publication. My thanks are due to the Research Council of the Australian Association for the Advancement of Science for providing financial help towards the cost of illustrations. Unfortunately it was not possible to find here artists experienced in this type of work, and also, after the figures were made, new conditions made available the receipt and study of much important additional material. Better preserved types were chosen in many cases, and certain figures rejected, but rather than postpone any longer the publication of much data urgently wanted by stratigraphers, it was decided to make a start. Apparatus is now available for the regular production of figures, and any inadequacy or absence of illustrations in the present two papers will be rectified shortly.

The most important immediate objective is the description and discussion of the more important stratigraphic species, long ranging or variable forms such as most Lagenidae being omitted. For this reason I am not adopting the usual procedure of describing total faunas, locality by locality; much of such descriptive work is unnecessary and to geologists unimportant, and present circumstances necessitate more concern with stratigraphically and commercially useful key forms.

The Upper Cretaceous and Tertiary of New Zealand is almost a virgin field. Stache and Karrer in 1864 incompletely described two faunas from horizons in the Mid-Oligocene and Lower Miocene. Their figures are idealised, and the species often misunderstood. Chapman's Bulletin (1926) was unfortunately based on poor material and lacked direct contact with the field geologists, and is consequently so full of errors of synonymy, identification and age conclusion that practically a fresh start must be made. Parr has already begun this work in several papers, and occasional species have been reviewed or described by Cushman. At the present time identification or union with external species is of less importance than elucidating

internal ranges; names mean little, utility much. Most of the collections originally studied were made in Poverty Bay under the auspices of the Vacuum Oil Co. during a geological reconnaissance for oil. The rapid work necessitated giving personal locality numbers, and I have since continued this practice for ease of reference in the Survey collections. These numbers will be largely quoted, for the sake of local workers and future check reference; the series 1000, 2000, 3000, and 4000 were collected by Vacuum geologists, from 5000 onwards are my own, and those prefaced by G.S. refer to standard locality numbers of the New Zealand Geological Survey. I have also, for the same reasons, made considerable use of certain local formational names adopted in Poverty Bay; these have mostly not been published, but are in general use there, along with the Survey's correlatives from other districts.

Paratypes of all species described and examples of any others discussed will be forwarded to the Cushman Laboratory, Sharon, Mass., and also to the Parr collection, Melbourne. The actual types are in all cases in the New Zealand Geological Survey collection. Other authentic specimens will in most cases be available for interested foreign workers willing to reciprocate.

Genus *VULVULINA* d'Orb., 1826.

Subgenus *SEMIVULVULINA* n. subgen.

Genotype: *Textilaria capitata* Stache, 1864.

This segregation differs from typical *Vulvulina* in the initial and terminal development, chamber formation, and markedly in range. *Vulvulina*, typified by *V. capreolus* d'Orb., is more primitive in its early development, appears in New Zealand in our earliest Eocene, and is abundant up to the present; *Semivulvulina* is less advanced in final development, does not appear here till the Mid-Oligocene (though apparently in the Mexican Lower Eocene), and does not last beyond the Lower Miocene.

In true *Vulvulina* the coiling of the first few chambers is as markedly developed as in *Spiroplectammina*. The generic description is usually given, following Cushman, as "early stages biserial, or slightly coiled in the microspheric form," as a matter of fact, though both forms display this feature, it is the smaller megalospheric one that develops it far more, as is shown by Cushman's own figures (1932; pl. 10, figs. 6, 9—megalospheric; figs. 7, 8—microspheric). In *Semivulvulina* the coiling is apparent in the megalospheric shell (though to a smaller extent than in *capreolus* and its allies, where a relatively large area is spiral), and practically non-existent in the microspheric form, which tapers to an acute point. In *Vulvulina*, though many of the specimens found may be biserial, adults nearly always occurring with them show that two to eight large transverse uniserial chambers are normally developed. In the new subgenus, the great majority of specimens are regularly biserial, much resembling *Spiroplectammina* of the *dentata-carinata* type, and only in the most fully grown shells is there finally developed a single uniserial chamber—even this is asymmetrical and does not extend across the test, having more analogy with *Loxostomum* than with *Recto-*

bolivina. The aperture, too, remains incompletely developed—not symmetrical, closed and central as in *Vulvulina*, but depressed and open at one end where the base of the chamber was. Its development from the typical Textularian aperture of the young shell (a simple gap at the base of the chamber, longest across the thickness) does not seem to be the simple gradual lengthening in the direction of width seen in *Vulvulina*, but proceeds by perforation; the upper lip of the early aperture remains as a bridge behind which one or more gaps open in the base of the terminal depression; the bar or bars thus formed between openings are finally more or less absorbed.

The distinctness of shell habit has already been noted by Cushman (1932, p. 82) in discussing *V. pectinata* Hantken (Lower Oligocene of Hungary) and *V. mexicana* Nuttall (Lower Eocene of Mexico), both almost certainly members of the new subgenus. The low angle and but slight curvature of the sutures is much more characteristic of this group than of true *Vulvulina*.

***Vulvulina* (Semivulvulina) capitata** Stache.

1864. *Textilaria capitata* Stache: *Reise de Novara*, Pal., vol. 1, p. 270, pl. 24, figs. 10a, b, c.

With this species must be synonymised two other forms described at the same time and from the same locality by Stache; *T. carinata* d'Orb. var. *antipodum* (l.c., p. 272, figs. 21a, b, c—*maorica* used in explanation of plate) and *robusta* (l.c., p. 272, figs. 22a, b, c—*inflata* used on plate). These are all individual forms of a not very variable species and have already been united by Chapman (1926, p. 32), though under the wrong names *Spiroplecta carinata* d'Orb.

The species is characterised by very sharply carinate sides, with a narrow but distinct, opaque, and frequently serrate flange; angle of expansion about 60°; more or less strongly limbate sutures; little coarse grained matter in the test, which is mostly of fine cement; and the presence of a more or less sharp medial angulation.

This is one of the most useful and reliable key species of the Oligocene. It is not always present in coeval samples, but tolerates a wide range of sediments, from glauconitic marl to limestone. It is sometimes replaced by typical *Vulvulina* and at a few localities the two occur together, notably in the Cobden limestone, where they are both abundant at locality 5361 (Runanga road, several hundred feet above base).

Its time range when abundant is strictly Upper Ototaran, though odd specimens may be found up to Lower Hutchinsonian; in this range it is widely spread over New Zealand. It is absent from all Waiarekan and Lower Ototaran localities, such as Lorne, basal Kaiata mudstone, and the rest of the Kaiata sequence, including the lower Point Elizabeth beds; Cormacks limestone just above diatomaceous earth; and lower Kakanui limestones (typical Lower Ototaran). It appears in the following Upper Ototaran localities: 5181 (Upper Kakanui limestone), 5359 (Upper Point Elizabeth), 5360 and 5361 (Cobden limestone; quite typical), many Whaingaroa localities, and G.S. loc. 1910,

Swinburn River (but not in the Lower Ototaran G.S. 2101 from same district). It is very uncommon in the Poverty Bay Oligocene, but is present at 1146A (Mangapapa Stream, Motu S.D., just below Ihungia). As regards the Dunroonian, it is not in the Wharekuri lower greensands of Fisherman's Rock, nor the middle greensands (though both these seem Upper Ototaran on foraminiferal evidence), but occurs at every locality in the upper greensands (Kekenodon beds); it is not uncommon and quite typical at G.S. loc. 1897 (Wendon Valley, Waikaka subdivision), a facies of the Chatton beds, though it has not been seen at Chatton. It is present at G.S. loc. 2108 (near Otorohanga, in the Te Kuiti series), which is in other respects very like Dunroonian. In the Porangahau district it is present in beds of about the same age (5388). Occasional specimens have also been found at four localities in the Poverty Bay Wheao beds (just above Oligocene); three of these are from the Whangaroa lowest dark mudstones (3143, 3144, 3017), the fourth from the Mangatu River (5394).

An interesting occurrence, together with other Upper Ototaran forms, is in the limestone at Tioriori, Chatham Is., where the only identifiable fossil apart from foraminifera is the abundant mollusc *Notostrea tarda*, a form simulating *Gryphaea*.

The line extends into the Waitakian (as the next described species) and a few Hutchinsonian localities, but is absent from every subsequent horizon. Lithologically there is a suitable facies at localities 5363 and 5364 (just above the Cobden limestone near the village), which appear to grade from the limestone and to have a Dunroonian and a Wheao fauna; typical *Vulvulina* continues on in abundance, but *Semivulvulina* disappears. There is a superficially similar form occasionally found in the Hampden (5178), Waitangi (4005), and Hurunui (5570) Bortonian, but adults from the last locality show several uniserial chambers and a different apertural development from *capitata*; it is in fact so close in details to *V. advena* Cushman (1932, p. 84, Pl. 10, f. 14), from the Jackson Upper Eocene of America, that it may be referred to that species. Also in the Hurunui Upper Bortonian (5573) is a smooth typical *Vulvulina* strongly resembling the Mexican Eocene *V. colei* Cushman (l.c. p. 84, Pl. 10, f. 21, 22). In the Awamoan are occasionally seen specimens like the early stages of *Semivulvulina*, but adults show that they really represent a *Spiroplectammina* allied to the Recent *pseudocarinata* Cushman.

***Vulvulina* (*Semivulvulina*) *waitakia* n.sp.** (Plate 68, Figs. 1a, b).

Directly descended from *capitata* and with the same terminal chamber, aperture and initial development. The barring across the aperture seems to be more persistent, and a developed terminal chamber with closed in aperture even rarer. A particular feature is the test formation; the bulk of the shell is fine cement, but a row of coarse sand grains is incorporated just above the sutures, leaving upper two-thirds of chambers quite smooth, the lower third and the medial join roughened. This takes the place of sutural limband and the joins of chambers are otherwise linear and not well marked. The form differs at sight in its slenderness, the angle of expansion

being only 30° to 40°. The sides are sharply carinate but have convex approaches and no trace of flange or serrations. The medial angulation is quite bluntly rounded.

Height up to 1.3 mm.; width, 0.7 mm.; thickness, 0.4 mm.

Holotype from locality 4409 (White Rocks, on road 2 miles west of Duntroon), chalky limestone above Duntroonian.

The species is abundant at the type locality and occurs also in the coeval Otiake beds (type of Waitakian). It seems to occur also a little lower. Specimens from G.S. 1825 (10 chains South of Wharekuri Bridge, hillside 100 feet above road level) are nearer to *waitakia* than to *capitata*; this is the highest Wharekuri horizon and is probably close to Waitakian. An anomalous feature is the occurrence of a few specimens at "The Earthquake," near Duntroon where a Duntroonian brachiopod fauna occurs. Either, then, the ranges of the two species overlap or the Duntroonian and Waitakian stages are very close, with the Wharekuri upper greensands and the Chatton beds somewhat lower than Duntroonian yet probably higher than Upper Ototaran. The latter seems more improbable than that the Duntroonian and Waitakian are only separable zones (on molluscs and brachiopods) in the South Island type district, but for stratigraphic purposes practically indistinguishable in most other areas. There seems to be no certain distinction in the Foraminifera, and the fauna which in the Cobden, Otorohanga, Pirongia, and perhaps Poverty Bay districts occurs between Ototaran and Hutchinsonian is best referred at present merely to the prior Waitakian.

The *Semivulvulina* line terminates with a few occurrences of the species *waitakia* in the true Hutchinsonian (Lower Miocene). A few juveniles at Clifden, bed 6A, probably belong to a true *Textularia* line, but undoubted examples are at 5054 (Trelissick Basin, tuffs between limestones, with *Calcarina mackayi*), 5275 (Greymouth Blue Bottom, with *mackayi* at the same horizon nearby), 3003 (Whakau Stream, Poverty Bay, with *mackayi* and abundant *Nephrolepidina* and *Miogyopsina*), and 5056 (Takaka, Terakohe marl quarry, below *Cyclocypeus* zone). It has not yet been found in the actual Waitemata beds where *C. mackayi* is also abundant; the zonal importance of the latter is discussed later in this paper.

GENUS TEXTULARIA DeFrance, 1824.

Textularia awazea n.sp. (Plate 69, Figs. 2a, b).

Test fairly large, elongate, somewhat compressed initially, rather inflated terminally. Microspheric form with an initial smooth pointed tongue of many chambers indistinctly defined and probably about eight on each side, then developing about five normal chambers on each side. Megalospheric form with about nine normal chambers on each side and a carinate spiroplectine apex of several chambers. Chambers initially about a third to half as high as wide, rapidly increasing later, final chambers subequal in these dimensions. Early ones moulded into the general medial convexity of shell; later ones becoming individually flatly convex, with a well-developed more or

less sharp spine on keel at lower two-thirds jutting outwards and downwards at same angle as chambers. Sutures more distinct on later half of shell, there rather broadly and shallowly excavate; initially faintly limbate, inclined at about 20° to horizontal; medial sutures sub-linear and less marked. Sides strongly carinate, but keel interrupted by the sharp spines with broad bases, except initially, where it is sharply serrate. Aperture the normal crescentic slit, rather widely open, rounded at the sides and rather short, except in senile shells. Test typically consisting of sand grains of varying sizes, few of them large, except in terminal chambers, set in abundance of cement, the whole surface smoothly finished.

Height of holotype, 2 mm.; width, 1.7 mm.; thickness, about three-quarters width.

Holotype from Pukeuri, 4 miles North of Oamaru, Awamoan (middle Miocene). Identical forms are at Awamoa Creek (type of Awamoan), Mount Harris, Target Gully, Ardgowan, but not at other South Island Awamoan localities, such as Rifle Butts, All Day Bay, etc., where the next species is common. It also occurs at several localities in the type Tutamoe beds of Muddy and Island Creek, Poverty Bay, though much less commonly.

The full range of this species cannot be given yet, but it seems to be characteristically an Awamoan form, doubtfully occurring in the Hutchinsonian or Taranakian. These spined Textularias are an extremely common feature of the New Zealand Miocene, but after the description and figures for the above species had been prepared, it was discovered that there are two rather similar species, apparently quite distinct and of different range, though occurring together at some localities. The second species is briefly described below in order to make it available for use by local stratigraphers. It is much commoner, has a considerably longer range, and will be more fully dealt with and illustrated in a later paper.

Textularia miozea n.sp.

Shell closely resembling the previous species, but in every way coarser and stouter in build. General details of chamber formation and shape, sharp lateral keels, aperture and the distinctions between microspheric and megalospheric forms are extremely similar. The spines are less well developed; often absent, usually restricted to blunt serrations or occasional fistulose projections and only exceptionally strongly projecting. The test is regularly built of much coarser material (this is usually one of the best features of distinction) and though the cement is just as abundant the sand grains preferred are mostly larger and frequently dark coloured; the surface is sometimes smooth but more often roughened by the coarse grains. The species reaches a much larger size, though having about the same number of chambers. It is relatively wider, with a greater angle of expansion and considerably stouter at all stages, normally almost as thick as wide.

Height reaching 2.5 mm.; width, about 1.3 mm.

Holotype from Geological Survey locality 1342, Poverty Bay, Patutahi S.D., Waikura Stream, about 2 miles 60 chains E.S.E. of

Poha Trig, immediately below Tutamoe-Ihungia boundary. At this locality *awazea* also occurs, though somewhat rarely, while at Ard-gowan the abundant *awazea* is accompanied by occasional specimens of *miozea*. They are easily distinguished when occurring together.

Typical specimens are common in the Hutchinsonian and throughout the Ihungian, and are also present, though much more rarely, in the Taranakian, but the Opoiti form differs. The lower limit is also definitely known. No *Textularia* of this type occurs in the Waitakian or lower horizons; as these are referred to not higher than the Oligocene the range of *miozea* strictly begins with the Miocene. The absence of this species or *awazea* in any sample where large *Textularias* do occur is practically sufficient evidence for a pre-Hutchinsonian age.

A fauna from the topmost part of the Te Kuiti formation (5348) contains *miozea*, and appears to be Wheao rather than Waitakian in age.

Genus SIPHOTEXTULARIA n.genus.

Genotype: *S. wairoana* n.sp.

Similar to *Textularia* in all respects, except that the aperture is a distinct short, slit-like tube, not at the margin of the chamber but in the apertural face. Here may be included also such forms as *heterostoma* Fornasini, which have a very elongate, asymmetrical slit, *aperturalis* Cushman, where the adult has the extremely long aperture divided medially, *catenata* Cushman, where the adult opening becomes subterminal and rounded—in fact, all *Textularias* whose aperture has risen above the contact of the two last whorls and is entirely surrounded by a raised lip. Practically all these species are subquadrate in section, instead of suboval or subrhomboid shaped, as in true *Textularia*, and nearly all are much smaller in size.

Cushman (1911, p. 23) has already noted that "Such species . . . have clearly essential characters different from the typical species of *Textularia*." The great mass of species in this genus needs some subdivision other than that provided by the spiroplectine commencement, and the fact that these tube-apertured forms have evidently developed from those with simpler opening and that most stages to the extreme *catenata* type can be found is no valid reason for suppressing the significance of the unorthodox aperture. *Plecanium concavum* Karrer is probably one of the best known examples of this, but the frequency with which it has been misidentified and the rarity of the true species have militated against its selection as a genotype. Forms of the *heterostoma* type similar to the figures of Heron-Allen and Earland (1916, pl. 40, figs. 22, 23) are common throughout the New Zealand Tertiary, but I have not had access to the original figures or reliable specimens, so have also eliminated this species as a type.

The name *Plecanium* Reuss 1862 has been used by some older writers for this group, though species of *Textularia*, *Spiroplectamina* and *Dorothia* were also included. The genotype of this has been designated by Galloway (1933, p. 227) as *Textularia labriata* (sic)

Reuss. Lalicker has stated (1935, p. 49) that "The aperture of *T. labiata* is at the margin of the chamber and only has a lip at the upper margin" (the species he there describes as *Textularia lajollaensis* would fall under *Siphotextularia*). This would make *Plecanium* a synonym of *Textularia*, as it is usually regarded.

***Siphotextularia wairoana* n.sp. (Plate 68, figs. 2a, b).**

Shell small, composed of small sand grains set in much fine cement, rather smoothly finished. Initially compressed but very rapidly thickening and for practically its whole length markedly quadrate in section with sharp angles to the sides. In front view, lower third or less rapidly widens, thence much more slowly. A small apical proloculum, then about six chambers on each side, twice as long as high, encroaching on and merging into adjacent ones; sutures not distinct, chambers flattish, slightly swollen along upper margin and the long keels, leaving medial part of shell as a wide, shallow excavation. In side view, surface practically flat, chambers slightly corrugate basally. Apertural face narrow, horizontally compressed with a medial, small, slit-like tube-aperture at an equal distance from upper and lower margins and very slightly asymmetrical.

Height, 0.48 mm. (type); thickness, somewhat more than half width.

Holotype from locality 3120, Mangataikohu Stream, Waimata S.D., Poverty Bay, mudstone with Wairoan fauna.

The species is common in the New Zealand Lower Pliocene, especially in the Wairoan facies (Waitotaran) and in the succeeding Nukumaruan, but has not been found in the Upper Pliocene Kai-iwi and Castlecliff beds. It is present down to the base of the Pliocene, being in several Opoiti localities (4322, Pov. Bay; G. S. 2329, Takapau, together with *heterostoma*). In the South Island it is not uncommon in the Waitotaran of the Bourne sandstone (5567) and Caroline Creek (5565), Amuri district.

Genus GAUDRYINA d'Orbigny, 1840.

Subgenus PSEUDOGAUDRYINA Cushman.

***Gaudryina (Pseudogaudryina) proreussi* n.sp.**

This species is directly ancestral to the common Oligocene *G. reussi* Stache (1864, p. 171, pl. 21, figs. 11-16) and differs from it only in a few small but constant details. The most important differential feature concerns the angles of the test. In *reussi* these are bluntly rounded, acute only for a very short distance or more usually blunted right to apex. In microspheric form three strong angulations remain up to final chambers, in megalospheric form the angles tend to disappear at the upper third or quarter of shell and the last two to four chambers are of the usual convex biserial type, their sides fairly regularly flatly rounded. In *proreussi* the angles are very high, prominent and sharp, much more compressed and acute at all stages, and extend in both forms over the whole shell, weakening only slightly in the last chamber, where the apertural angles are blunt and discontinuous with the previous keel; the total effect, especially in the microspheric form, is to make the sides between keels notably

concave, whereas in *reussi* their convexity is always more or less apparent. The microspheric form of the new species is stouter and wider and the initial expansion of its angles considerably greater, about 40° to horizontal, instead of to vertical, as in *reussi*. The megalospheric form differs at sight in the absence of unangled terminal chambers. The aperture is on the whole smaller, though the shell is larger. The suture lines between chambers are usually less distinct and excavated. After this species was distinguished, much better specimens were found at Hampden, and the holotype chosen will be figured later.

Height, up to 3.5 mm.; width, up to 2.5 mm. (microspheric form). Megalospheric form about three-quarters this size or smaller.

Holotype from Hampden, 1½ miles North of Kakaho Creek, upper blue clays, about 5 ft. below top. Collected by J. Park. This is near the top of the Bortonian.

This is one of the most useful species for distinguishing the Bortonian from the overlying beds and Oligocene. It is an abundant and characteristic form throughout the Upper Hampden section from the top of the Kakahoian marls (including the "Marly Clay" with *Zeauvigerina*) down to and including the greensands, i.e., the whole Bortonian. It is replaced by quite definite *reussi* in the very topmost Hampden sample from a locality at the extreme north of the section and exposed only at very low tide; for this and other reasons the bed is regarded as Tahuian. It is present in the Bortonian of Waihao Downs and in the McCulloch's Bridge lower greensands below the phosphatic band, but is clearly replaced by *reussi* in the Upper more fossiliferous greensands at the latter locality—the type Tahuian. This is one of the few Foraminiferal distinctions available for separating Bortonian and Tahuian, but it appears constant and valid. The foraminiferal fauna of the Burnside marl which has been variously classed as Eocene or Oligocene is definitely referable to the Tahuian on this and other counts. From this horizon *G. reussi* extends upwards commonly through the whole Ototaran, but is not known to me from any Duntroonian or Waitakian facies. Towards the end of its range its presence is sometimes useful in distinguishing an Upper Ototaran from a Duntroonian fauna. The ancestral *G. proreussi* indicates by its presence the Bortonian age of such other beds as the Pahi greensands, the Waitangi marls of Poverty Bay, the chalk marls below the Amuri limestone and the *Asterocyclina* bed of White's Creek, North Canterbury, which is the same horizon as the Eyre River type locality of *Discocyclina speighti* Chapman (1932, page 483); these orbitoids were classed by Chapman as middle Eocene, which, from other viewpoints, also seems to be the best age for the Bortonian.

As regards a lower limit, the bed of greensands which forms a middle stage of the Moeraki-Hampden section is extremely poor in fossils, but has yielded a few specimens of *proreussi* and some calcareous species of the upper marls, so that this bed should be included in the Kakahoian Bortonian. The Moeraki glauconitic marls below this (including the "Moeraki boulders") have a quite distinct series of faunules, consisting of only arenaceous species, but not including

G. proreussi. These sandy species are often different from those in the beds above, so this absence is significant. It is most unlikely to be due to facies, for in none of the numerous uppermost Cretaceous samples seen from elsewhere in New Zealand has *proreussi* appeared, though often common in overlying Eocene beds. It is at present, then, one of the most reliable and significant index species of Bortonian age. The same range is kept by a few calcareous species which will be described in due course.

As regards the generic name, I am unable to accept it as of 1839, the date always quoted. When d'Orbigny originally introduced the name (*Hist. Nat. Cuba*, Foram., p. 109) he gave no species, and the genus was then only a theoretical concept as regards publication. Further remarks on this matter are made later under *Rectobolivina bortonica*, but in the present case I regard *Gaudryina* as dating from 1840 (*Mém. Soc. Géol. France*, ser. 1, vol. 4, p. 43), when the first named species was described. In this case the alteration fortunately affects nothing.

The group of large species to which *reussi* belongs is evidently that of the American *atlantica* Bailey and *jacksonensis* Cushman, which has lately been split off as *Pseudogaudryina*. Parr (1935, p. 83) described two middle Tertiary species as of the *reussi* group, but they belong to an altogether different line, abundant in New Zealand from Oligocene to Recent, while the *reussi* lineage does not reach the Miocene.

All the other five species of *Gaudryina* described originally by Stache and retained as varieties by Chapman (1926, pp. 34, 35) are to be synonymised with *reussi* as entirely individual variants of no stratigraphic or biologic significance whatever.

Genus RECTOBOLIVINA Cushman, 1927.

Rectobolivina bortonica n.sp. (Plate 68, Fig. 6).

Test attenuate, subcylindrical, slightly compressed initially. The distinctly biserial part occupies a little less than half length of adult shell, but change to uniserial chambers is rather gradual and uneven, later chambers appearing somewhat staggered, so that outline of test is usually uneven, seldom straight. Although final chambers are distinctly uniserial, even the end sutures are not horizontal to axis, but resemble those of some *Nodosorella* species. Microspheric form gradually tapering to pointed initial end. Megalospheric form with a large proloculum and blunt apex; 4 to 5 succeeding chambers on each side are Bolivine, then about 6 adult chambers irregularly uniserial. Aperture about one-third width of shell, terminal, central, oval, with no lip at either end, but an indistinct ridge at one side and a definitely higher lip on opposite side. Sculpture at first sight complex, but shell is in reality practically smooth, with very characteristic pore development. Approximately the upper half of each chamber is almost perfectly smooth and glassy, any pores being extremely minute. The lower half has a dense system of conspicuous pore channels radiating at an angle through the shell wall; the total effect gives on the initial whorls a

false appearance of striation, on the later whorls an alternating effect—a pitted suprasutural area followed by an upper oblique translucent band. Sutures linear, fairly well marked, chambers slightly convex and about two-thirds as high as wide.

Height, up to 0.9 mm.; width, 0.12 mm.

Holotype from loc. 5371, type Wanstead (Motuotaria S.D., main road 1 mile south of Wanstead Hotel).

This is an important and abundant index species of the Wanstead and Bortonian. It is almost invariably present in the many Wanstead samples seen from the Dannevirke area, and occurs also at several places in the Eocene Waitangi marls of Poverty Bay and in the Pahi marls. At all these localities it is associated with the genus described elsewhere as *Zeauvigerina*. It is present, though somewhat rarely, throughout the Kakaho marls at Hampden, thus covering the whole Bortonian. It is not known outside of this middle Eocene range, being conspicuously absent in the abundant Tahuian fauna from the Burnside marl.

The new species is evidently closely allied to *Bolivina applinae* Plummer, which has been referred to *Loxostomum* by Nuttall (1930, p. 285, pl. 24, fig. 45), but which evidently is better placed in *Rectobolivina*. Nuttall notes that *applinae* has fine longitudinal surface striae and crenulate indentations along the base of the chambers, the biserial portion being over half the shell—these details allow of immediate separation from *bortonica*. Another ally appears to be the Lower Oligocene *Bifarina vicksburgensis* Cushman (1929, p. 45) from the Byram marl; it has the somewhat staggered chambers, but the early periphery is serrate and the coarse perforations are differently distributed.

The use of the generic name raises the question of related genera. The present position of species variously referred to *Sagrina*, *Loxostomum*, *Bifarina*, *Rectobolivina*, *Siphogenerina* and *Tubulogenerina* seems to me in a state of some confusion, and often anomalous. The groupings adopted illustrate well certain defects of the system of genus-making and systematic location by means of theoretical definition, as opposed to lineage grouping round the type species. The former method holds complete sway at present in the Foraminifera but has not been very satisfactory in other groups and, while apparently simple, leads to a loose and contradictory use of genera, as seen in many families of the Foraminifera. It is absolutely contrary to the International Rules to regard a genus as a wordy concept. Article 25 makes it clear that a genus name is invalid unless "the author has applied the principle of binary nomenclature," and a genus without species does not conform to the principles of binary nomenclature. Genera conceived only by definition cannot have any but a personal claim to acceptance; opinion 2 unequivocally states that "names based upon hypothetical forms have no status in nomenclature." It seems to me that some concepts in the treatment of Foraminifera need modification if these ideas are logically applied.

Galloway synonymises *Rectobolivina* with *Bifarina*, and by theoretical definition this is right, but the Recent *R. bifrons* does not seem happily placed with the Cretaceous *B. saxipara*. Cushman retains both genera, with the distinction that *Bifarina* is not compressed and has a strong neck and lip. It is unfortunate that the genotype of *Bifarina* is based on a section, so that the external details are hard to visualise, but Cushman's diagnosis does not fit it well and the Recent species he illustrates in addition (*fimbriata* Millett) is not much like *saxipara*. Study of actual specimens of *fimbriata* shows that its generic relationship to *bifrons*, *columellaris*, *dimorpha*, *advena*, etc., is too close for this separation. The whole question is too complicated to discuss here and I have no material of Ehrenberg's species available, but am inclined to regard *Bifarina* at present as of uncertain status and use *Loxostomum* for Bolivine species regularly biserial but with aperture finally becoming closed off at base; *Rectobolivina* for species with an early conspicuous biserial part followed by some uniserial chambers with terminal, central aperture; and *Siphogenerina* for forms without a biserial stage between the initial triserial and final uniserial ones, even in microspheric form. This, of course, is subject to modification, as the affinities of the type species are considered, but is a working hypothesis.

***Rectobolivina parvula* n.sp. (Plate 68, Fig. 5).**

Test minute, cylindrical, slightly compressed initially. Megalospheric form with a large blunt proloculum followed by four biserial chambers, then five uniserial, a little over half as high as wide, increasing gradually in this respect. Microspheric form with a somewhat smaller but still blunt apex, about six biserial chambers. The uniserial character is very sharply taken on, the suture being horizontal at once. In the megalospheric form all these chambers are even, forming a regular cylinder. In the microspheric form there is a constriction at the end of the biserial stage, thence the chambers slowly but regularly widen. Surface extremely finely and densely punctate but appearing smooth, no trace of sculpture. Sutures distinct but hardly differing in level from chambers. Aperture terminal, central, suboval without rim.

Height, 0.3 mm.; width, 0.005 mm.

Holotype from locality 5105 (Citrini's area, near Kumara, probably high in the Hutchinsonian).

The exact range of this species is still somewhat doubtful, as it is never common and its minute size makes it easily overlooked. It occurs at several Tutamoe localities of the Muddy Creek area in Poverty Bay, but has not been found in the underlying Ihungian. It is present, however, in several samples from the West Coast "Blue Bottom" above the Cobden limestone. These may not all be the same age; some seem to be near the Hutchinsonian-Awamoan contact, but others are almost certainly Hutchinsonian and may correspond to faunas from low in the Ihungian. It is also not uncommon in several samples from Jedburgh "Grey Marls" of the Cheviot district, whose fauna is definitely Taranakian.

The small size, even for the genus, and simplicity of character render comparison with other species unnecessary.

Genus PLECTOFRONDICULARIA Liebus, 1903.

Plectofrondularia parri n.sp. (Plate 68, Figs. 4a, b).

Shell very close to *P. floridana* Cushman from the Miocene of Florida (see for example *U.S. Geol. Surv.*, Prof. Paper 175A, p. 22, pl. 7, fig. 11, 1933) and evidently representing that species in New Zealand. There are the same doubly sigmoid suture lines, high and broken medially, but flattening to almost horizontal at sides. There is the same narrowly elongate shell, oblong in section, with three keels forming each edge. The shape is slightly different, the New Zealand shell having a slightly smaller angle of expansion, especially in the later half where the sides tend to become subparallel. The most striking difference is in the sculpture; in *floridana* there is a single very short median costa over the first few chambers; in *parri*, though occasionally the shell is almost smooth, there are normally two costae, a little weaker than the keels and equally dividing the area between them, running more than halfway up the shell, occasionally with traces of a third.

Height, up to 1.4 mm.

Holotype from locality 5273, All Day Bay beds, Kakanui Beach, 60 chains at 150° from Trig V (Awamoan). At this locality and others in these beds the species is abundant, but these samples were not seen till after a figure had been prepared. The figured example is from Pukeuri, where unfortunately the species, though well preserved, is rare and mostly smaller and much smoother than the normal Awamoan shell. Hutchinsonian examples, such as those from the All Day Bay *Pachymagas* bed and the Weka Pass Grey Marls, are mostly considerably smoother than those from Awamoan localities, but there is too much individual variation to separate them easily from *parri*. The holotype will be figured later.

This name will be available for the forms Chapman (1926, p. 55) has misidentified as *bicostata* d'Orb. and *tenera* Bornemann. The latter is a true *Frondicularia*, but even Chapman's figure shows the biserial early chambers.

The species is named after Mr W. J. Parr of Melbourne, who has rendered me much assistance. It has a Hutchinsonian-Awamoan range; a few specimens are known from one Whaingaroan locality (1279), and one Duntroonian horizon (G.S. 1825), but otherwise the species has not been seen below basal Hutchinsonian. It is common in the Awamoan and Tutamoe, but is replaced in the Upper Miocene by the following closely related form.

Plectofrondicularia pohana, n.sp. (Plate 68, Figs. 3a, b).

Extremely close in all respects to *parri*, but differing in having less convex sutures not suddenly raised medially.

Size, same as *parri*.

Holotype from Amuri Subdiv., Cheviot Surv. Dist., "grey marl" 30 chains S.W. of Trig Sub Y (Jedburgh marls—Taranakian).

The species is not uncommon in marls from the Cheviot district which have commonly been lithologically correlated with McKay's Grey Marls. There is, however, little resemblance in the foraminifera, the latter being lower Hutchinsonian (Basal Miocene), while the former is definitely Taranakian (Upper Miocene). It has occurred in numerous other Taranakian localities, notably in the Mapiri beds near Tinui. Just as *parri* is the New Zealand ally of *floridana* Cushman, so is *pohana* the local representative of another well-known American species, *P. californica* Cushman and Stewart (1926, p. 39, pl. 6, figs. 9-11). This Pliocene species is very close to the Miocene *floridana*, differing (from the figures) only in less convex sutures—exactly the same evolutionary difference as appears in New Zealand.

Genus NOTOROTALIA n.gen.

Genotype: *N. zelandica* n.sp.

This genus is proposed for the group of Rotuline shells clustered round the well-known *Rotalia clathrata* Brady (1884, p. 709, pl. 107, figs. 8, 9). They are distinguishable at sight by their complex *Elphidium*-like sculpture, differing from that genus only in their asymmetry. The great majority of Austral specimens have hitherto mostly been identified as *clathrata*, but it is shown below that this is a Recent South-East Australian form separable from those of New Zealand. In this country only one of the many species has so far received a distinctive name, and that is *Rotalia clathrata* var. *spinosa* Chapman (1926, p. 85) from the Miocene. This was described from three localities, but two quite distinct species were confused, so I here select Pukeuri (Awamoan, Middle Miocene) as type locality, and name the figured specimen as lectotype.

Several Australian forms have been discriminated. Heron-Allen and Earland (1924, p. 181, pl. 14, figs. 114-116) figured a Lower Miocene species as *Rotalia reticulata* Cushman, described from the Miocene of America; Chapman, Parr and Collins (1934, p. 566, pl. 9, figs. 20a-c), in rejecting this record, described the Australian species as *Rotalia howchini*, though the figures in the two publications are somewhat difficult to reconcile. There are at least three species of this group in the Balcombian beds at Muddy Creek, none of which is quite like the figures given. Cushman has described two more Australian species under the generic name *Polystomellina* (1936, p. 87), *P. miocenica* from the Lower Miocene, and the Recent *P. australis* from North Queensland.

Reference to these various figures will show that a very compact group is represented. *Polystomellina* is certainly a better location than *Rotalia*, but is not satisfactory for several reasons. The Japanese genotype *P. discorbinoides* Yabe and Hanzawa is a trochoid shell with only the dorsal side convex, the base being flat. Its ornament consists mostly of porous radial sutures and shows no trace of the heavy clathration or reticulation characteristic of the *Notorotalia* group. It and *Faujasina* are regarded as derivations from *Elphidium*, but the parent stock must have been one of the simpler smoothish

species with small retral processes. The diverse type of shell formation and sculpture makes *Polystomellina* an unhappy location for the Austral group, which seems to be associated more with the heavily and coarsely sculptured species of *Elphidium*.

Attention should be drawn to the aperture of the new genus. All of the descriptions and most of the figures quoted give this incorrectly. It has been variously described as "The normal arched fissure at the inner margin" (Brady), "An arched opening at the base" (Chapman, Parr and Collins), "A low opening at the peripheral margin, extending slightly to the ventral side" (Cushman). These are all misleading; I have never seen a true apertural opening in this group. A slight hollowing out may occur along contact with base and last chamber, but it does not continue inwards; the whole apertural face is a solid wall overrun by the heavy sculpture-ridges. The meeting of these with the base has somewhat the effect of producing cribrations, but in perfectly preserved shells there is no trace of a real opening. It is possibly unnecessary, as the whole shell is so porous and the terminal face so extremely thin and perforate. This complete absence of true aperture is regarded as highly diagnostic, and of course at once prevents any connection with *Rotalia*. It is extremely easy to get a wrong impression of this aperture if the shell is in the slightest degree broken or worn. A number of the strongly spirally sculptured species of *Elphidium* show the same aperture, while others have a row of pores in the terminal face.

Such a species as *Elphidium imperatrix* Brady (1884; pl. 110, figs. 13-15) must be very closely connected with the *Notorotalia* line; it shows the same development of peripheral spines as the Middle Tertiary New Zealand forms, has the same aperture and the same type of strongly ornamented proloculum. Apart from its perfect symmetry, it is in fact a *Notorotalia*. Another prominently spinous Indo-Pacific form is *Rotalia trispinosa* Thalmann (*pulchella* d'Orb., auct.), but the aperture and development show plainly that this is unrelated to *Notorotalia*, and is a true *Rotalia* of the *beccarii* type.

***Notorotalia zelandica* n.sp.**

This species is best described by comparison with *Rotalia clathrata* Brady. That species was described from "Four Stations between Australia and New Zealand" and "Two Stations on the West Coast of Patagonia." Brady noted that the latter were different, as is shown by his figure 9 (from Station 305, West Coast of Patagonia). His figure 8 was from Station 162, 38-40 f., off East Moncoeur Island, Bass Strait, and this must be taken as the typical form; if it has not been done before I now choose as lectotype of Brady's species the Australian specimen which was the original of his figures 8a, b, c.

Forms of this kind are extremely abundant in shallow water all around New Zealand at the present day, and a long ancestral line is known. The common Recent New Zealand form does not appear to be the same, however, as the Australian. I have not seen Recent samples from there; it is not present in my samples from 7 fathoms Derwent Estuary, Tasmania, and it is not in any of the large Peronian or Solanderian faunas I have available. It seems to be

more at home in a colder climate, though Heron-Allen and Earland have noted that it dies out as the sub-Antarctic is approached. Specimens I have from the Pliocene of the Abbatoirs Bore, Adelaide, (recently referred to the Lower Miocene *howchini* by Howchin and Parr, but not the same as any Muddy Creek lower bed species I have seen) agree in general with Brady's figure and, using this as a basis, one notes many differences in the New Zealand Recent form. The latter grows much larger (up to 1.4 mm.), while Brady's type was only 0.8 mm. The New Zealand shell has a relatively blunt periphery, the medial keel being masked by nearly similar ridges above and below it, and the sides not shelving steeply to meet it as in *clathrata*. The Australian shell is mostly domed above and fairly flattish below, but *zelandica* is nearly always flatly depressed above and more convex basally, especially just inside periphery. The central part of the base is notably depressed or excavated, with an umbilical pitted area as in *Elphidium*; *clathrata* has a more evenly flattened base and smaller pitted area. The sculpture of *clathrata* between the limbate sutures consists of relatively few and distant irregular ridges, the spirals on the ventral side unwinding slowly; *zelandica* has much heavier and closer intra-sutural ridging, the ridges on the upper two-thirds of each chamber pointing steeply outwards at about 80° to spiral suture, but on the lower two-thirds of chamber suddenly altering slope to about 45°, evenly covering whole surface between radial sutures. On the basal surface the spirals unwind much more rapidly and are frequently discontinuous at sharp angles from chamber to chamber. Microspheric form regularly spiral; megalospheric form with a large proloculum minutely papillate all over.

Diameter of adults, 1 to 1.4 mm. Height somewhat variable, about half diameter in adults and somewhat less in young.

Holotype from upper part of Castlecliff beds, Uppermost Pliocene; chosen in preference to a Recent specimen, as the latter are mostly worn and therefore show weaker sculpture. Figures of this and aperture details will appear later.

This Recent and Upper Pliocene species is characterised chiefly by its large size, rounded or bluntly sub-angled periphery, with a greater convexity below it than above. It occurs also in the underlying Nukumaruan (mid-Pliocene) but is not known as yet from the Waitotaran or Opoiti stages (Lower Pliocene).

Numerous Tertiary species are known from all horizons back to the Bortonian, where very rare and tiny forms may indicate the beginning of the lineage, but have all essential characters, such as aperture, perfectly developed.

***Notorotalia stachei* n.sp. (Plate 69, Figs. 3a, b).**

Shell small, depressed biconvex, but often flattened above or below. About 2½ whorls, with eight to nine chambers in last one, distinct ventrally, obscure dorsally. Whole dorsal surface covered with short, strong, blunt ridges, masking sutures in most cases; where clearly developed they are seen to consist of 5-6 subparallel cords with subequal interstices, as strong as or stronger than the limbate radial sutures and completely crossing the chambers between

the latter at approximately right angles to them, but more frequently they become so irregular and towards the centre especially so anastomose and twist that accurate description is impossible. Ventral surface much more clearly sculptured, the radial sutures distinct, limbate, with about seven subequal ridges, $1\frac{1}{2}$ to 2 times their width apart, not parallel but radiating irregularly fanwise; here again the general effect is frequently one of indefinite direction. Umbilical region very small, with hardly any plug or papillae. Dorsal surface often with a number of irregular swollen bumps. Periphery sharply carinate, expanded into a narrow but marked thin translucent flange, undulating with chambers; it may or may not bear a number of quite irregularly-spaced tiny flatly-compressed spines. Aperture normal for the genus, with no opening but the pseudo-clefts formed by the overridden sculpture.

Diameter, up to 0.6 mm.; height, about one-third diameter.

Holotype from locality 4407, Wharekuri greensands, 300–400 ft. downstream from Fisherman's Rock. These are the middle greensands and have a fauna recognisably distinct from the lower ones at Fisherman's Rock itself and Wharekuri Bridge, and also distinct from the upper Kekenodon beds. The middle and lower greensands are referable by their faunas to the Upper Ototaran; in the probably Duntroonian upper greensands a quite different species of *Notorotalia* occurs. The specimens from the lower greensands are even smaller in size and rather battered, but more resemble *stachei* than they do any other Ototaran form. The species has also occurred at locality 5306 (middle Kakanui limestone, above tuff) and as a single specimen at 5181 (Uppermost Kakanui limestone), but has not been seen from any lower or higher horizons, where very different species occur. This makes it a strictly Upper Ototaran key form of considerable value. It has not occurred anywhere in the samples from the Cobden limestone or just above it, which is probably due to the preference of the genus for shallower water; the same reason probably explains the absence of any member of this group from the Maungatapere. It is present at G.S. locality 1910 (Swinburn River, S.E. of Naseby), and is quite typical and often abundant at several localities in the Whaingaroa beds—one of the best pieces of evidence for referring this horizon to the Upper Ototaran. Abundant specimens from Kawhia (5577) (mudstone, bedded with volcanic agglomerate), match in every detail with the Wharekuri types, and it is strange that Stache did not discover this very distinct form.

Genus NUTTALLIDES n.gen.

Genotype: *Eponides trümpyi* Nuttall 1930 (*Journ. Pal.*, vol. 4, no. 3, p. 287, pl. 24, figs. 9, 13, 14. Eocene, Mexico).

Test rotaliform, more or less planoconvex, with a strong tendency to develop a peripheral flange. Sutures sloping back at sharp angle dorsally, somewhat markedly sinuous basally. Umbilical area usually with a prominent boss of clear material. Aperture a linear slit with a sharp, projecting outer edge, extending from plug almost to periphery, where it suddenly turns backwards into the flange, like *Pulvinulinella*.

The discovery of abundant specimens in the New Zealand Eocene of a species closely related to the Mexican Eocene *Eponides trümpyi* is very interesting. The Mexican form was recorded by Nuttall as frequent in the Chapapote (upper) and Aragon (lower) members of the Eocene, but not outside this age. In New Zealand, specimens are common in the Upper Bortonian and apparently less so in the Lower Bortonian. It has not occurred in the Tahuian (Uppermost Eocene) but a closely related form is present in the lower and middle Rakauroa (Upper Cretaceous). The New Zealand Eocene form is best described by comparison with *trümpyi* as follows.

***Nuttallides subtrümpyi* n.sp.**

Shell of entirely the same build and general features as *trümpyi*, with similar dorsal and ventral sutures. The flange is much sharper; Nuttall described and figured "a rounded peripheral flange," but New Zealand specimens have a fairly acute, bevelled, translucent peripheral border. They are distinctly planoconvex, the dorsal side being mostly flat or slightly raised medially, while *trümpyi* is apparently biconvex. This feature varies somewhat, but the New Zealand shell as a whole presents a recognisably different shape from Nuttall's figures. An immediate distinction is the character of the ventral boss; this, in *trümpyi*, is mentioned and figured as rounded, and does not disturb the basal outline; in *subtrümpyi* it is almost always quite flat over its whole area, the basal outline being thus sharply truncated. The dorsal surface and to some extent the ventral has a heavy layer of translucent shell material evenly spread all over, through which the sutures are visible, the central ones indistinctly where the layer becomes thickest. This feature is not mentioned by Nuttall, who figures the central portion as clearly as the rim.

Diameter, up to 1 mm. (*trümpyi* averages 0.7 mm.); width, two-thirds to three-quarters diameter.

The figures prepared for this description did not show the essential details clearly, and illustrations will be given in a later paper.

Type from locality 3310, greasy marl, Matakoho Survey District, Auckland, 1 mile north-west of Pahi, Paparoa Arm. This is interbedded with greensands of the Pahi series, contains also *Zeauvigerina* and *Hantkenina* and is definitely Upper Bortonian. Elsewhere the species extends throughout the Bortonian (but not above), with a few rare specimens, possibly a distinct species, from the uppermost Cretaceous.

The reference of this type of shell to *Eponides* can hardly be upheld. *Nautilus repandus*, the genotype of *Eponides*, is a common Indo-Pacific shell, and its lineage is continued well back in our Tertiary. Fairly typical specimens extend down to the Lower Miocene, but in the Lower (and perhaps Upper) Ototaran a distinct ancestor occurs. This differs in having a less-pointed base, a distinctly open umbilical area formed by the great spread of the aperture ventrally, and especially in having fewer chambers; regularly five to a whorl, instead of seven to ten as in *repandus*. This form is especially common in the Waiarekan tuffs of Lorne (G.S. locality 1100) and

may take the name of *Eponides lornensis*, new species. Chapman, Parr and Collins (1934, p. 565, pl. 9, figs. 18a-c) have recorded and figured *repandus* from the Australian Tertiary as far down as the Oligocene Balcombian; as they say, Muddy Creek examples seem inseparable from typical Recent shells, and the same applies to N.Z. examples from the Miocene onwards. Waitematan specimens occasionally look like *lornensis*, but adults always have six or more chambers.

All these true representatives of *Eponides* show the typical generic aperture, a widely open space entirely confined to the straight contact between the last whorl and base; its outer margin notably convex and with a wider gape ventrally before the umbilical union of the sutures is reached. In the ancestral *lornensis* it spreads into this area; in all forms there is a definite end at the periphery with no tendency to invade that area at a new angle. The apertural face in typical *Eponides* is usually more or less cribrate. Other species of *Eponides*, such as the American Tertiary *guayabalensis* Cole and the European Miocene to Recent *schreibersii* d'Orb., keep this type of aperture with not a great transition in shell features.

This is totally unlike the apertural features of *trümpyi* and its allies, with the angled lateral extension into the peripheral face, and as several diverse species are known with this type of aperture it is here made the principle basis for generic segregation, though general habit of shell and type of chambers are not without significance also.

I suggest as a congeneric species *Discorbina alata* Marsson, which has been figured and described as a *Pulvinulinella* by Cushman (1931, p. 311, pl. 36, figs. 5a-c). Specimens extremely similar to those there figured from the Saratoga chalk occur at locality 3250A, Tuparua Stream, Waipiro S.D., Poverty Bay, in marls of mid-Rakauroa age. The aperture in Cushman's figures is not altogether distinct, but the New Zealand specimens show exactly the *Nuttallides* aperture. The basal knob of clear callus is prominent only in juveniles, adult examples tending to surround this below with a basal ridge, forming a pseudo-umbilicus. The later figures of this species given by Cushman and Jarvis (1932, p. 48, pl. 15, figs. 1, 2) are less like the Tuparua and Saratoga specimens and more resemble in shape another species occurring in the New Zealand Rakauroa.

The development of the basal characteristics in *alata* lead me to suggest that the characteristic Upper Cretaceous species recorded by authors as *Gyroidina* or *Globorotalia micheliniana* d'Orb. also belongs to *Nuttallides*. Cushman's figures of Annona chalk and Antigua specimens show clearly the sinuous suture and flange development and the characteristic aperture. Also the pseudo-umbilicus, as in *alata*, is quite different from the pervious one of *Gyroidina*. Two other Cretaceous species certainly to be grouped with *micheliniana* are *Gyroidina alabamensis* Sandidge (Alabama Ripley) and *Globorotalia subconica* Morrow (Kansas).

Another genus which must necessarily be brought into the discussion is *Pulvinulinella* Cushman. The genotype of this is *P. subperuviana* Cushman, the description and figures of which show an

elongate aperture just below the periphery and entirely in the plane of coiling, without prolongation along the basal margin towards umbilicus. The aperture was originally described as "somewhat loop shaped," with the remark that the type species "does not show the apertural characters as definitely as do the Recent species." This was evidently overlooked by Chapman, Parr and Collins (1934, p. 569, pl. 9, figs. 19a-c) when describing the Australian Oligocene *tenuimarginata* as doubtfully belonging to this genus. In shell features it is quite like the genotype except for the straight aperture, which, however, is seen in Recent species such as *pacifica* Cushman. The Balcumbian form, which can be taken as generically typical, is abundant also in New Zealand, where it has an extended range from at least Lower Oligocene to Upper Miocene.

A series of such typical species shows that the *Pulvinulinella* aperture is well defined and not really much like that of *Nuttallides*, where the lateral extension, though definite, is merely an adjunct to the main aperture, and it is stretching the limits of the genus too much to include *alata* and similar types. The recently described *P. gyroidinaformis* Cushman and Gaudkoff (1938, p. 2, pl. 1, figs. 1, 2) has some unusual shell features but apparently a fairly typical aperture. Another type of aperture, however, which is decidedly atypical is that shown by *Planorbulina culter* Parker and Jones. This has been very generally referred to *Pulvinulinella* but some writers have questioned this, and Nuttall (1930, p. 293) has stated that the apertures are very different. The good figures given by Brady (*Chall.*, pl. 96, fig. 3c) and Schwager (1866, pl. 7, fig. 111; as *bengalensis*) clearly show that the striking feature of this aperture is an oblique slit in the end face, well below the periphery, opening out from the contact slit between base and last chamber, and descending well into the face at an angle about midway between basal and peripheral margins. A number of similar forms are known, including *mexicana* Cole, *velascoensis* Cushman and probably the lately described *texana* Cushman (1938, p. 49), which, though compared with *alata*, seems to have more the *culter* type of aperture and shell coiling. This kind of shell is common practically throughout the Tertiary succession in New Zealand, and the lineage extends into the Upper Cretaceous. The apertural and shell distinctions from *Pulvinulinella* and *Nuttallides* are here emphasised by the proposal of the new genus **Parrella**, with *Anomalina begalensis* Schwager as genotype. This form is chosen for the type instead of Parker and Jones' *culter* on account of the ambiguity associated with the latter. Chapman and Parr (1937, p. 119) have noted that the true *culter* differs from Brady's interpretation, which probably was equivalent to Schwager's species; since my remarks on apertures have been based on shells like Brady's and Schwager's figures, it is plain that *bengalensis* must typify the genus. These remarks were written before Chapman and Parr's were seen; their independent suggestion that a new genus is probably needed is much wiser than their unsatisfactory location in *Cibicides*.

Cushman has figured (*Contrib. Cush. Lab.*, vol. 14, pt. 3, pl. 11, figs. 4, 5) as *Pulvinulinella* two species which show very clearly indeed the characteristics of the two apertures, *glabrata* being a typical *Pulvinulinella*, while *navarroana* is plainly a *Parrella*.

It is fitting that the genus name should mark the independent research of Mr. W. J. Parr into this matter.

Genus CALCARINA d'Orb., 1826.

It is interesting to compare the aperture of *Parrella* with that shown by another rotaloid group. Brady's figure (*Chall. Rep.*, pl. 108, fig. 2c) of his *Rotalia venusta* shows a peculiar development, the aperture developing a rimmed slit projecting into the terminal face at an upward angle—the exact opposite of the downward spur in *Parrella*. Heron-Allen and Earland discovered this species abundantly in the Kerimba Archipelago, and though their figures (1915, p. 720, pl. 53, figs. 15–22) are concerned mainly with the shell development and do not show the aperture, they note its close alliance to *Rotalia calcar* (d'Orb.), occurring with it. This alliance is indubitable, and study of excellent specimens I have of *venusta* from 12 f., Cape Bedford, Queensland, and various forms of *calcar* from Malay Archipelago, Fiji, etc., together with their Tertiary relatives in the Parisian Eocene and Australian Miocene, makes it plain that the aperture keeps certain constant features, fundamentally distinct from true *Rotalia*. There is always a basic linear slit along contact of last whorl and base; this is not widely open like *Rotalia*, nor distinctly and roundly terminated at either end; it vanishes obscurely at the plug end, being concealed by the lobate overhanging termination of the chamber; at the peripheral end it expands into what is usually the only visible portion, a strongly rimmed slit with parallel sides, projecting suddenly into the terminal face at an angle of some 45° to the previous path in *venusta*, somewhat less in *calcar* and its ancestors. There is a general faint resemblance to the *Nuttallides* aperture, but the likeness is not really close, and they have arisen independently; the ornament and heavy basal plug in the *venusta-calcar* line is quite unlike anything seen in the other group.

This aperture is not at all like that of *Rotalia* and there is little except family affinity between the two. *R. trochidiiformis* Lamk., the French Eocene genotype of *Rotalia* has been fully discussed and figured by Cushman (1927, p. 124, pl. 24, figs. 5–7) and by Davies (1932); in ventral opening and dorsal surface it is practically identical with *Eponides*, and this has caused Galloway (1933, p. 281) to synonymise the two. But the complex structure of the ventral face and the possession of a distinct umbilical plug, apart altogether from the canal system, are valid distinctions for *Rotalia* and are observable in numerous Recent species living alongside of typical *Eponides*. In such forms as *beccarii* and even the complex *schroeteriana-conoides* group the aperture does not depart radically from the defined type, except in greater concentration, a tendency to closure in senility with development of subsidiary openings near the enormous plug.

The distinction of the *calcar* group from typical *Rotalia* has been recognised by both Cushman and Galloway, the former placing it in the separate family *Calcarinidae*, while the latter used the older name *Tinoporus* as family basis. But in each case the sundering was made on the complex shell features exhibited by the more specialised genera, and little heed was paid to the aperture. Cushman wrote "The family in its simplest forms is close to *Rotalia*, in fact *Calcarina calcar* may be a *Rotalia*," while Galloway stated that "if the family consisted only of the genera *Calcarina* and *Tinoporus* it could well be left in the *Rotaliidae*." To the rather slight distinctions Galloway gives between *Calcarina* and *Rotalia* I would now add as a primary feature the distinctive aperture, and though I do not accept the complete groupings of either author, the development of the more complex genera from the simpler *calcar* line seems clear, and separate family rank justified. Cushman includes more genera than Galloway; whatever may be the objections to some of them, there can be little doubt of the affinities of the Cretaceous *Siderolites* Lamarck, 1801—the oldest generic name in the family. It is the practice of many outstanding workers on mollusca and other groups to take the earliest genus name as automatically fixing that of the family, but this position has not been taken in Foraminifera, and in view of the numerous alterations it would cause in classification, I hesitate to adopt it. Yet I personally feel that this is the safest and most logical method, for obvious reasons, and that a family *Siderolitidae* in the present case will some day be used. The question of authorship of family names is immaterial and leads to much useless personal controversy.

It is to be noted that Cushman and Galloway have used the name *Calcarina* in different senses, and the validity of its interpretation must be considered. Cushman's interpretation is based on his Philippine Report (1919, pp. 363–368, and 1921, p. 351), where he considered that "The type species of *Calcarina* is *Nautilus spengleri* Gmelin. This species is definitely taken as the genotype by d'Orbigny"; at the same time (p. 354) he recognised and figured Montfort's *baculatus* as a valid species, though suppressing his generic name *Tinoporus* on the ground that his diagnosis did not agree entirely with his figure and evidently included specimens of *Baculogypsina sphaerulata*. Galloway (1933, p. 312) disagreed with this, regarding *Tinoporus* as a valid name, based on the figure, and giving the genotype of *Calcarina* as *calcar* "by absolute tautonymy and designated by Parker, Jones and Brady, 1865." As regards the former contention, it seems obvious that since *baculatus* is recognisable, *Tinoporus*, whatever the diagnosis, was introduced with one valid species, and only one, and is therefore a monotypic genus; as it represents the earliest name for the *spengleri-defranci-mayori* group it must be used. As for the second contention, Cushman later (1933, p. 312) pointed out that the complete statement of Parker and Jones was not free from ambiguity, and continued to regard *spengleri* as the type. But d'Orbigny did not definitely designate types, and the question of tautonymy was passed over by Cushman. Article 30 of the International Rules, however, gives a number of cases gov-

erning type designation, to be applied in definite order of precedence—cases 1a, b, and c do not apply in the present instance, but 1d states that “If a genus, without originally designated or indicated type, contains amongst its original species one possessing the generic name as its specific name or subspecific name, either as valid name or synonym, that species or subspecies becomes *ipso facto* type of the genus.” This adequately covers the case of *Calcarina calcar* d’Orb., 1826, whatever other species he included, and *Calcarina* is thus the valid name for the *calcar-venusta* group, as distinct from *Tinoporus* for the heavily spiked, secondarily thickened species.

The discussion of this family and generic name is necessary here, since *Calcarina* has been credited with a New Zealand Tertiary species, which is quite unrelated, while an important index species which truly belongs here has been obscured by a wrong location elsewhere.

***Tinoporus hispidus* (Brady).**

This, as *Calcarina hispida*, has been reported from the New Zealand Oligocene by Chapman (1926, p. 87; pl. 17, fig. 9) as an initial fossil record of the species. All reference to the record and to the species in New Zealand should be expunged; nothing remotely like this Recent tropical shallow water species occurs in this country, Recent or fossil. I have examined Chapman’s type and slides and much topotype material from Flat Top Hill, and what Chapman had is quite evidently a species of *Notorotalia*, very abundant here. Similar shells covered with minute spines have been seen only at Landon Creek, Everett’s Quarry, and the uppermost limestone at Kakanui Point—all Upper Ototaran horizons. It is difficult to see the details exactly on account of bad preservation, the deposits having been subjected to re-crystallisation by percolating water, but it is almost certain that the “spines” are secondary calcite crystals and have nothing to do with the original shell structure. Similar spines appear on parts of other species in these beds, though this genus seems peculiarly liable to develop them; specimens in the Bridge Point green tuffs are sometimes finely spinose, sometimes partly and irregularly coated, sometimes smooth. I have already (in Allan, 1938, p. 90) drawn attention to this species, which will be described later from better preserved material; apart from the pseudo-spines, the Duntroonian form is very different, and Dr. Allan’s argument is not affected. *Tinoporus*, however, can be completely dispensed with in New Zealand.

While on this subject it may be mentioned also that all reference to and records of “*Rotalia papillosa* var. *compressiuscula* Brady” must be deleted from the New Zealand area. There is nothing in this country recalling this obvious relative of *schroeteriana*, a true *Rotalia*, which genus is represented in New Zealand only by a form of *beccarii*. Heron-Allen and Earland recorded the species from “a few fossil specimens” in the “Terra Nova” Report, and Chapman (1926, p. 86) has identified it from the Weka Creek Grey Marls (Basal Miocene). Since on his type slides the same form is variously identified as *Pulvinulina elegans* and *P. karsteni*, and mixed

indiscriminately with at least two other genera, not much weight can be allowed to this record. His specimens are once again a species of *Notorotalia*, close to his own *spinosa*.

***Calcarina mackayi* (Karrer).**

1864. *Rosalina mackayi* Karrer; *Novara Exp.*, Pal., vol. 1, p. 82, pl. 16, fig. 14.

Described from the Lower Miocene Waitemata beds of Orakei Bay, this species has been misunderstood ever since. Chapman (1926, p. 85) referred it to *Rotalia*, "as closely related to *Rotalia beccarii*," but there is not even family resemblance. Karrer's figure is somewhat idealised, but good specimens for a new figure are hard to find as the form is very restricted. The aperture, not shown by him, is distinctive. It is of the same general style as already described for *Calcarina*, but differs in some details; the slit along contact of base and last whorl is absent or filled in and the large slit in the terminal face is considerably lower down than in *calcar*. This gives the appearance of an isolated opening slightly removed from and at a small angle to the contact margin, outlined by a strong rim all round. This development seems not a far step from the typical, and probably well-preserved juveniles would show gradation; indeed there is some evidence of it in Australian specimens.

C. mackayi is strictly limited to that part of the Hutchinsonian represented by the Waitemata beds, and is very rare in New Zealand. It is a large and characteristic species, but has so far been seen from only four other localities. At the first, 3303 (Whakau Stream, Tutamoe S.D., Poverty Bay), it is not uncommon (though badly preserved) in company with enormous numbers of orbitoids, mostly *Nephrolepidina*. This is the only locality in New Zealand where free orbitoids are abundant; it is an isolated outcrop, but from other evidence probably marks the base of the Ihungia, and can safely be correlated with the Waitemata series. This is in keeping with Marwick's record of the Waitematan index molluscan genus *Paracomina* from the Igneous Conglomerates of the basal Ihungian. The two other localities are 5277 ("Blue Bottom" sandy marl, 6 miles S. of Greymouth, 4 miles E. from coast), and 5054 (Trelissick Basin, tuff between limestones, junction of Porter and Thomas Rivers). Both these represent the same Hutchinsonian horizon as the two previous; from similar tuffs at Whitewater Creek, not far from 5054, Thomson has recorded the index Hutchinsonian brachiopod *Pachymagus parki*. The final locality is from basal Mahoenui, 4 miles N. of Pio Pio (5579), where the species occurs with abundant *Semivulvulina waitakia* Finlay.

This *Calcarina* apparently occurs also in Australia; specimens are rather common at Torquay (Lower Miocene) and seem to differ little from the New Zealand ones. The characteristic aperture is quite the same, as is also the case in abundant specimens from the Lower Miocene of Filter Quarry, Batesford, though the latter are highly nodulose and evidently a distinct species. This discounts the references by Heron-Allen and Earland (1924, p. 181) and Chapman (1909) of this form to *Rotalia calcar*. The aperture and shell ornament are distinguishable at sight and the Batesford species has

rightly been described as new by Howchin and Parr (1938, p. 310, pl. 19, figs. 8, 9, 11, 15), under the name *Rotalia verriculata*. The reference of the flatter spineless accompanying form to *C. defranci* can hardly be upheld—it also seems to occur in New Zealand.

Genus CIBICIDES Montfort, 1808.

Cibicides parki n.sp. (Plate 69, Figs. 1a, b).

Test biconvex, with considerable variability; sometimes dorsal surface low and ventral projecting medially; sometimes ventral almost flat and dorsal raised into a high dome. Umbilical region always obscured by raised corrugations. Periphery expanded into a wide, thin, transparent flange which undulates but continues the dorsal curve to overhang immediate ventral surface; broadest and most transparent on side opposite aperture, reduced to vanishing point on last chamber. Chambers about seven to nine, increasing in number with age; very indistinct dorsally, except near aperture, those of earlier whorls entirely hidden by the punctate, semitranslucent surface material; ventrally more distinct, separated by narrow, deep, undulating grooves, which become more obscured the further from the aperture. Base very heavily and characteristically pustulose-corrugate, the pustules massing irregularly between and about the sutures towards the umbilical area, which has some heavy, short, raised ridges quite irregularly directed and anastomosing; pustules rapidly becoming obsolete towards outer half of base, which eventually is smooth, except for fine perforations. Dorsal surface just as characteristically ornamented with very coarse, tubular perforations, entering sideways and reminiscent of *Siphonina*; they are prominent over most of triangular surface of chambers, but these areas are separated from each other and from the concentric sutures by smooth, opaque areas; the whole surface seems to be coated with a subtranslucent layer, through which earlier whorls and their coarse punctae are indistinctly visible. Last chamber normal dorsally but frequently with irregular, inflated areas and a smoother surface ventrally. Aperture small; heavily rimmed ventrally, forming a semicircle round flange to join base just inside it; rim almost flush with surface dorsally, but running back short distance to join suture acutely.

Diameter, up to 0.9 mm.; thickness, half to two-thirds diameter.

Holotype from locality 5068, Burnside marl, Tahuian (Upper Eocene).

This is one of the most characteristic, ubiquitous and important species of the New Zealand Lower Tertiaries. It is present in abundance in all kinds of lithology in practically every Eocene deposit. Fine examples are present throughout the glauconitic marls of the upper Hampden beds, and the specific name is chosen partly to acknowledge the help Prof. Park has rendered in collecting from and elucidating these beds, and partly to give one of our most useful index species the name of this pioneer in our palaeontology. *C. parki* is as widespread throughout New Zealand as it is in facies locally, and I have it from the Amuri chalk marls, the Dannevirke Wanstead, the Poverty Bay Waitangi marls and cores, and the North Auckland

Pahi marls and greensands, in most of these cases from localities too numerous to mention separately. Abundant in marls and chalky limestone, it is just as common and well-marked in almost pure greensands, such as at McCullogh's Bridge and Waihao Downs.

It is not, however, limited to the Eocene. In the lower Ototaran it is quite as plentiful and characteristic in the deeper water sediments, such as the siliceous fine limestone of Cormacks immediately above the Oamaru diatomaceous earth, the lower Kakanui limestones corresponding to the true Oamaru limestone, and the Kaiata mudstones. It is absent, however, in such very shallow water faunas as the basal Ototaran (Waiarekan) of Lorne, and the tuffs below Oamaru limestone at Rifle Butts and All Day Bay. Certain other typically Eocene species persist into the lower Ototaran with it, but there are numerous key species by which the associations can be distinguished. On the West Coast this species is abundant from the so-called "Island Sandstone" base of the Kaiata mudstone up through that formation and into the lower Point Elizabeth beds, but it is completely lacking from there through the rest of the Ototaran, as it is also in the Upper Kakanui limestones and the Whaingaroa and Te Kuiti beds. Its definite absence from all samples of the Poverty Bay "Maungatapere" (though it occurs in the Eocene Te Hua series beneath) is further evidence for relegating this formation to the Upper Ototaran.

The species is so abundant in the Bortonian that one may suspect its occurrence still earlier. The only evidence for this as yet, however, is the presence of a single specimen at locality 5104 (Manawaangi Gorge, Mangaotero S.D.) associated with *Rzehakina* and other typical Upper Cretaceous species in a fauna which is undoubtedly Rakaurua. It is therefore to be looked for in these beds, but its occurrence in abundance is a sure sign of Eocene—Lower Oligocene age.

APPENDIX

Some explanation should be given of the basis on which European stage-names have been used here. As there are practically no definite direct means of correlation, any system must be more or less artificial and dependant on the accuracy of initial hypotheses. The stratigraphical order of a large number of units or stages is known in New Zealand, all of which have been defined by their content of molluscs or brachipods. These have been spread over the Tertiary and artificially allotted to the broad European divisions by various workers; one of the best known published tables being that of Marwick (1927, p. 573) whose distribution was as follows:—

Eocene	.. ..	Wangaloan, Bortonian, Tahuian.
Oligocene	.. ..	Waiarekan, Ototaran, Hutchinsonian.
Miocene	.. ..	Awamoan, Taranakian.
Pliocene	.. ..	Waitotaran, Nukumaruan, Castlecliffian.

Still later, in another stage discussion (1931, p. 3), he referred Wangaloan to Danian or Montian. The application of some of these names has been considerably revised and new ones have been proposed. Wangaloan has been more definitely referred to the Danian

by Finlay and Marwick (1937, p. 15). Waiarekan I would eliminate entirely as merely a basal facies of the lower Ototaran; if used at all it should be only in a zonal sense. The new term Duntroonian has been proposed by Allan (1938, p. 89) for a stage directly above the Ototaran, and directly below the Waitakian, which name was proposed long ago by Park for the Waitaki limestone, known now to underly the Hutchinsonian. As pointed out in this paper, though the distinction between Duntroonian and Upper Ototaran is valid as Allan set forth, the separation from Waitakian seems impractical elsewhere in the absence of good molluscan and brachiopod faunas, and the differences may again be merely zonal or even facies. A term is possibly needed for the Lower Hutchinsonian, characterised by less evolved *Pachymagas* of the *hectori-haasti* type, leaving the true Hutchinsonian for the faunal horizon of *P. parki*, *Rhizothyris rhizoida*, and the *Waiparia-Neothyris* association. At least one new stage, though of small extent, seems to be needed between the Hutchinsonian and Awamoan, as shown by the Clifden and Poverty Bay sequence; the higher Clifden and Mt. Brown beds with *Stethothyris sufflata* and *Neothyris novara* being very probably an Awamoan facies—they are not recognisable elsewhere and the mollusca are close. The Opoiti series has been recognised by Ongley (1928, p. 7) as a necessary unit between the Taranakian and the Waitotaran; it is well marked in the North Island and from the Foraminifera belongs in the Wanganui System. In order to have a definite stage name available I here propose the *Opoitian Stage* for the interval of time represented by the depositions of the beds quoted by Ongley as between the Mapiri series and the Waitotaran (represented by his Waihua beds, the Ormond and Tokomaru being of uncertain and varying age and better dropped altogether), together with such periods as may be represented therein by non-deposition or erosion. Faunally, I define this stage as characterised by abundance of *Rectobolivina* aff. *bifrons*, the first appearance of *Patellinella*, *Bigenerina* aff. *nodosaria*, *Globorotalia inflata*, *Siphotextularia wairoana*, *Sigmollina* n.sp., and *Plectofrondicularia* n.sp., and the last appearance of *Haeuslerella* and many long-ranging Miocene lineages.

In allotting all these stage names to the broad European divisions, molluscan and brachiopod workers have been hampered by the frequent poverty or absence of faunas from critical horizons. I have now seen large foraminiferal faunas from every stage mentioned, with the exception of Wangaloan, and my conclusions have been reached solely from their study, though I have naturally utilised my experience with the two other groups. I have taken two outside levels and one fundamental hypothesis as guides in drawing up the table here suggested, and its validity depends on theirs. The levels are:—Middle Eocene age for the Bortonian, because of the occurrence of *Discocyclus* and *Asterocyclus*, and Lower Miocene age for the Hutchinsonian, because it is almost without exception the horizon of *Nephrolepidina* spp. and *Miogypsina*, and correlates with the Australian Janjukian, already referred to that age. The hypothesis is that the major observable faunal changes will most likely be at the dividing planes between Eocene, Oligocene, Miocene and Pliocene; there is definite evidence elsewhere that this is not so, and therefore

may not be so here, but it is a provisional suggestion. The Hutchinsonian, Awamoan and Taranakian are much closer inter-allied faunally than they are to the beds above or below.

Finally, the Ototaran, so poor in molluscan fossils, and only locally rich in brachipods, has become an unwieldy unit now that its numerous rhizopod faunas are known. The Lower is more distinct from the Upper than are the Hutchinsonian and Awamoan, and names are obviously needed for both. For the lower, Morgan's old name Kaiatan (see Allan, 1933, p. 91) can be revived; it is founded on a unit of known stratigraphic position, and can be determined faunally by the presence of *Cibicides parki*, *Martinotiella robusta*, *Pseudogaudryina reussi*, *Notorotalia* n.sp., *Bolivina* cf. *reticulata*, *Globigerinoides* sp. and several other forms. For the upper, I here propose the *Whaingaroan Stage* founded on the Whaingaroa Series of the North Island West Coast. I define it as the period of time represented by the deposition of the Whaingaroa clay-stones or sandy marls below the Te Kuiti limestone, as well as such intervals as are represented therein by non-deposition or erosion; and I cite as a characteristic assemblage *Notorotalia stachei*, *Semivulvulina capitata*, *Rotaliatina sulcigera*, *Polymorphina lingulata*, *Pseudogaudryina reussi*, *Margulinina hochstetteri*, *Martinotiella robusta*, *Globigerina angipora*, the absence of *Cibicides parki*, *Globigerinoides* and *Globigerina triloba* and the initial appearance of several later Tertiary lines. The Waiarekan has been restricted to tuffs (see Allan, 1933, p. 96), and cannot be used as equivalent to Kaiatan; it is a basal zone of that formation.

The suggested table is:—

Pliocene ..	Upper	Castlecliffian	
	Middle	Nukumaruan	
	Lower	{ Waitotaran Opoitian	
Miocene ..	Upper	Taranakian	
	Middle	Awamoan	
	Lower	Hutchinsonian	
Oligocene ..	Upper	{ Waitakian Duntroonian	
	Middle	Whaingaroan	} (Ototaran)
	Lower	Kaiatan	
Eocene	Upper	Tahuian	} (Waimatean)
	Middle	Rortonian	
	Lower	—	

For convenience of reference, I give the following list of new names proposed:—

GENERIC:

Semivulvulina n.subgen. (Fam. Textulariidae). Genotype: *Textularia capitata* Stache (Middle Oligocene–Lower Miocene).

Siphotextularia n.gen. (Fam. Textulariidae). Genotype: *S. wairoana* n.sp. (Eocene–Recent).

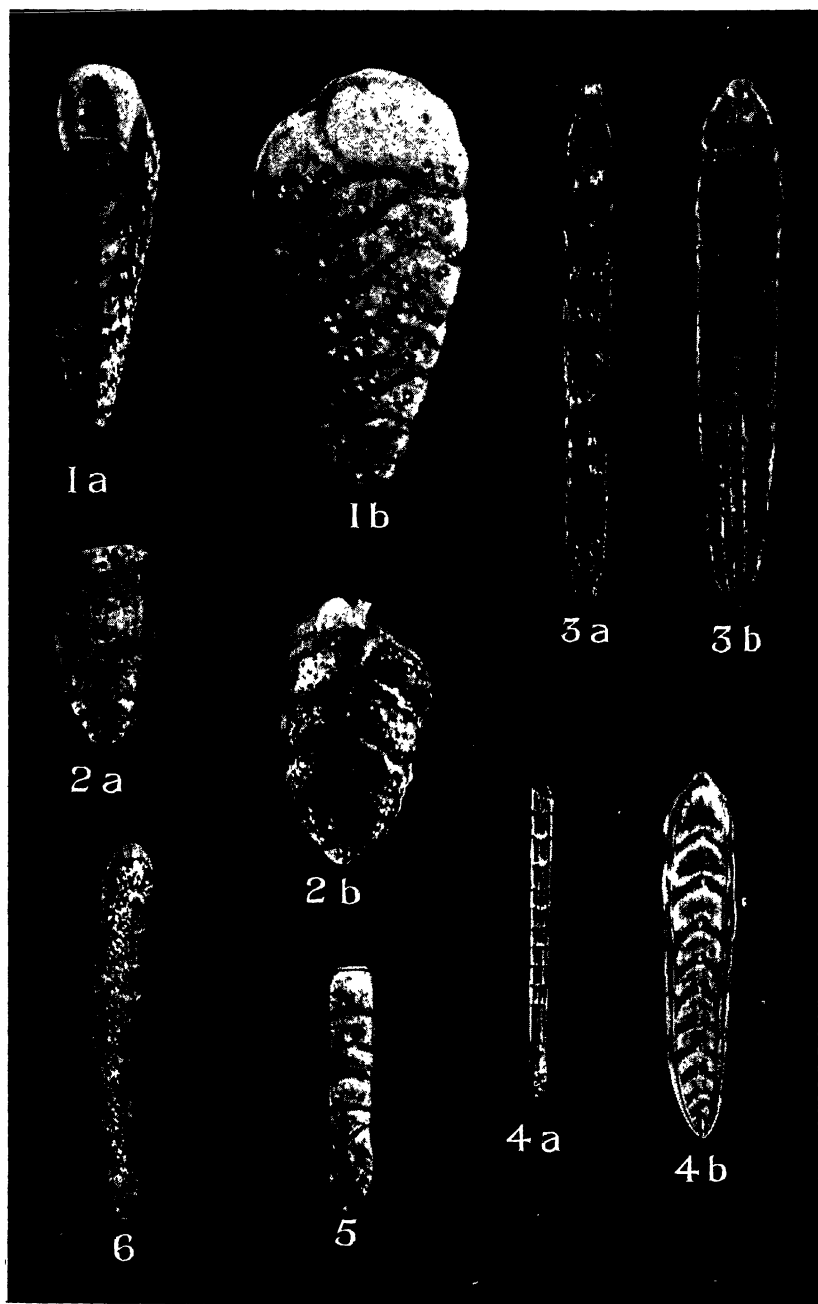
- Notorotalia* n.gen. (Fam. Rotaliidae). Genotype: *N. zelandica* n.sp. (*clathrata* auct, non Brady) (Eocene-Recent).
- Nuttallides* n.gen. (Fam. Rotaliidae). Genotype: *Eponides trümpyi* Nuttall (Upper Cretaceous-Eocene).
- Parrella* n.gen. (Fam. Rotaliidae). Genotype: *Anomalina bengalensis* Schwager (Upper Cretaceous-Recent).

SPECIFIC:

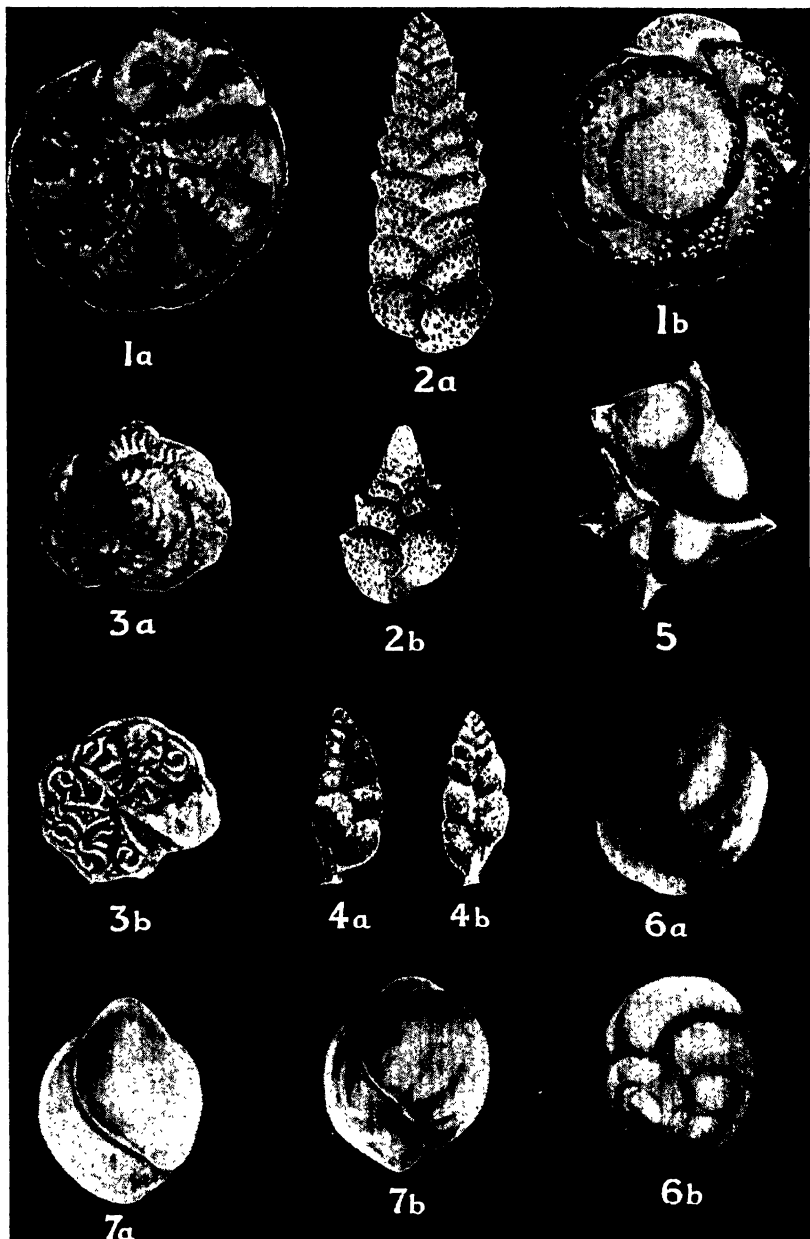
- Vulvulina* (*Semivulvulina*) *waitakia* n.sp. (Upper Oligocene to Lower Miocene).
- Textularia awazea* n.sp. (Middle Miocene).
- Textularia miozea* n.sp. (Lower to Upper Miocene).
- Siphotextularia wairoana* n.sp. (Lower and Middle Pliocene).
- Gaudryina proreussi* n.sp. (Middle Eocene).
- Plectofrondicularia parri* n.sp. (Lower and Middle Miocene).
- Plectofrondicularia pohana* n.sp. (Upper Miocene).
- Rectobolivina bortonica* n.sp. (Middle Eocene).
- Rectobolivina parvula* n.sp. (Lower to Upper Miocene).
- Notorotalia zelandica* n.sp. (Upper Pliocene-Recent).
- Notorotalia stachei* n.sp. (Middle Oligocene).
- Nuttallides subtrümpyi* n.sp. (Eocene).
- Eponides lornensis* n.sp. (Lower Oligocene).
- Cibicides parki* n.sp. (Upper Cretaceous-Lower Oligocene).

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FIGS. 1a, b—*Vulvulina* (*Semivulvulina*) *waitakia* n.subgen, n.sp.; 1a co-type, shows aperture bars too regular, 1b holotype, $\times 45$.
 FIGS. 2a, b—*Siphonotextularia* *waitoana* n.gen, n.sp.; 2a co-type, 2b holotype, $\times 90$.
 FIGS. 3a, b—*Plectofrondicularia* *pohana* n.sp.; holotype, $\times 60$.
 FIGS. 4a, b—*Plectofrondicularia* *parvi* n.sp.; Pukeuri paratype, $\times 60$.
 FIG. 5—*Rectodolivina* *parvula* n.sp.; holotype, $\times 120$.
 FIG. 6—*Rectodolivina* *bortonica* n.sp.; holotype, $\times 60$.



FIGS. 1a, b—*Cibicides parki* n.sp.; 1a holotype, $\times 40$.

FIGS. 2a, b—*Textularia arcacea* n.sp.; both microspheric, 2a holotype, 2b juvenile abnormally stout, $\times 20$.

FIGS. 3a, b—*Notorotalia stachei* n.sp.; 3b holotype, $\times 40$.

FIGS. 4a, b—*Zeuvigerina zelandica* n.gen., n.sp.; Pahi paratypes, $\times 80$.

FIG. 5—*Hantkenina australis* n.sp.; Waitangi paratype, $\times 40$.

FIGS. 6a, b—*Rotaliatina sulcigera* (Stache); Waitangi Eocene specimens, $\times 40$.

FIGS. 7a, b—*Rotaliatina sulcigera* (Stache); Awakino Oligocene specimens, $\times 40$.

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New Zealand Foraminifera: The Occurrence of *Rzehakina*, *Hantkenina*, *Rotaliatina*, and *Zeauvigerina*.

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THE four genera which form the subject of this paper are of more than local interest. During 1933 they were found at numerous localities in the Poverty Bay district; until then they had not been recorded from New Zealand. With the exception of *Rotaliatina*, they all occur in deposits older than any from which Chapman received samples. Hence, though often abundant, they are not noted in his bulletin (1926). He saw no real Cretaceous from New Zealand, though he recorded as such various samples from Eocene to Upper Oligocene, and the very little Eocene he had was too hard to yield these forms. Parr has since found some of these genera in Eocene material from Pahi, where I have known them for some years.

Wherever they occur throughout the world these genera are regarded as of small vertical range, and their few species are used as important index forms of the Upper Cretaceous and Lower Tertiary.

Genus RZEHAKINA Cushman, 1927.

Rzehakina epigona (Rzehak) is an abundant and characteristic index fossil of the uppermost Cretaceous in New Zealand, but seems somewhat local in its distribution. Outside of the Poverty Bay area it is seldom found and has not occurred in coeval deposits in the South Island. Cushman (1933, page 97) gives its range as Upper Cretaceous and doubtfully lowest Eocene, while Galloway (1933, page 97) inclines to regard all its recorded occurrences as Upper Cretaceous. Macfadyen has fully discussed its occurrence in South America (1933, pp. 1-16) and presents the evidence for and against its Eocene occurrence, leaving the matter still somewhat in doubt. It was originally described from Moravia, but the supposed "alttertiar" age of the deposit is almost certainly erroneous, the accompanying *Pseudotextularia varians* being regarded as one of the best indices of Upper Cretaceous age. However, the Mexican Velasco, in which *Rzehakina* has long been known, is now regarded as earliest Tertiary (Palaeocene) by Thalmann (*Proc. Geol. Soc. Am.* for 1934, p. 371, abstract).

In New Zealand it occurs over a fair range of horizons. Its lowermost limit is unknown, as it is present (though rarely) in the lowest beds from which foraminifera have been obtained; these indicate quite definitely an Upper Cretaceous age. Its upper limit is also somewhat in doubt, so that its New Zealand occurrences unfortunately still do not settle definitely whether it enters the Tertiary. It has been found several times in a fauna of undoubted Eocene age, but its possible derivation from lower beds is in each case open to

question. Since few detailed accounts of its occurrence have appeared, and as its index value is of considerable importance to local and even outside workers, a complete list of its known New Zealand occurrences is here presented. The variety *lata* Cushman and Jarvis (1928, p. 93; pl. 13, figs. 11a, b) described from the Upper Cretaceous of Trinidad has not been separable so far in New Zealand. It was stated to be more rounded and much larger than the typical Velasco form, and New Zealand specimens can certainly be matched with the description and figure, but in these features such enormous variation is obvious at any locality yielding a large enough suite that no good purpose is seen here at present in separating any variation from *epigona*. New Zealand specimens exactly agree with Rzehak's original figure. Variation does not seem to have any stratigraphic use and occurs at all horizons; two forms are found at most localities, a thick one and a smaller angular and very thin one (microspheric?) with more coils. No specimens in New Zealand, however, approach the thickness of *Silicosigmoidina* Cushman and Church (1929, p. 502, pl. 36, figs. 10, 11, 12), the extremely similar genus which is common in the Californian Upper Cretaceous Chico, and "occupies the same place in the fauna that *Rzehakina* does . . . in Trinidad."

The earliest records are from the "Puketoro" formation, which is probably equivalent to the Raukumara of the Survey. Mudstone at the top of the "Puketoro" (probably equivalent to the Mangataone) has yielded a few faunas—the only ones in New Zealand with true *Globigerina cretacea*—; two of these (3201 and 3203, Puketoro Stream) yielded one specimen of *Rzehakina*, while another (3180, Waitahaia River) did not. None were found in the red beds at the top of the Puketoro (3204), nor in Raukumara beds with *Inoceramus* in the Dannevirke area (5293 and 5302), but one specimen was again present in mudstone with *Inoceramus* (5109A, 15 miles south of Cape Kidnappers). In the Raukumara, *Rzehakina* is thus so rare in records and specimens that it is probably just becoming established in this faunal province.

The next formation, in contrast, provides abundant records and examples. The formational name Rakauaroa was used in Poverty Bay for a sequence of beds between Puketoro and undoubted Tertiary; the lower part of this was noted in Hikurangi and Mata survey districts as extensive conglomerates and other coarse sediments—this is quite possibly equivalent to the Tapuwaeroa of the Survey. *Rzehakina* is here abundant, with frequent large, stout specimens of the *lata* form (e.g., localities 3242 Mata S.D.; 3249 Waipiro S.D.; 3270 Mangaoporo S.D.; also in associated black shales). It is again abundant in coeval deposits from the Dannevirke area (5301, 5321, 5336 and many others), but it is not present in what is evidently a fauna of the same age from the South Island East Grey District (5329, mudstone below Amuri limestone).

The upper, more typical, Rakauaroa consists of finer grained, lighter coloured sediments, which are probably in part at least equivalent to the Survey's Whangai. In the Dannevirke area the argillites and chocolate shales of the Whangai have yielded no *Rzehakina*, but

odd specimens have been found in Poverty Bay samples lithologically referred to the Rakauroa, and it was abundant at locality 3250A (Waipiro S.D., light mottled marls, Tuparoa Stream; above lower Rakauroa conglomerates).

The succeeding formations are Tertiary. The lowest of these is the Te Hua series in Poverty Bay, equivalent to the Survey's Wanstead in Dannevirke. No true Wanstead or younger fauna has ever yielded *Rzehakina*, nor have South Island beds of equal age. It is missing in the whole Hampden section from the Cretaceous Katiki and Moeraki series through to the Bortonian (equals Wanstead) Kakaho marls. The red shales, however, provide the biggest problem, especially with regard to the possible Tertiary occurrence of this genus. No other beds in this series (chalky limestone, Te Hua marls, etc.) contain it, nor is it present in the whole series of cores from Waitangi No. 1 well, which seemingly pass through all the varieties of red and green shales and bentonitic earths met with on the surface; the faunas here are all typical Bortonian. But at two surface outcrops of red shales in the Waitangi fault zone (4012 and 1006) faunas were found which somewhat resemble the well cores, except in lacking calcareous species and in possessing abundant *Rzehakina* and *Bolivinopsis spectabilis* (Grzyb.). The latter species almost invariably accompanies *Rzehakina* and has much the same range, but seems to be more widespread. I can see no appreciable difference between this species, as figured from Burdwood Bank by Macfadyen (1933, p. 7, Fig. 1c, d, i, j), and the Trinidad shells identified as the later *clotho* (Grzyb) by Cushman and Jarvis (1932, p. 43, Pl. 13, Figs 5, 6), though Cushman (1934, p. 42, 43) left them separate. Both are very large and have the same accompanying fauna, and the New Zealand forms are certainly the same as the Burdwood and Trinidad ones. The other elements in the Waitangi red shales could easily be of Rakauroa age, so that either these and *Rzehakina* range into the Tertiary if the outcrops are correlated with the definitely Bortonian well cores, or else there is more than one "red shale."

The variability of *Bolivinopsis* in New Zealand is so great that the forms are difficult to deal with. In the chocolate shales at the very top of the Rakauroa (above the White Argillites) and in the Moeraki beds below the Hampden Bortonian there are irregular and distorted specimens with slightly shorter chambers, apparently exactly the same as the Californian Upper Cretaceous *B. californica* Cush. and Campbell (*Contrib. Cush. Lab.*, vol. 10, pt. 3, p. 70). But some of the New Zealand shells also recall "*Spiroplectammina*" *meriaensis* Lalicker (*l.c.*, vol. 11, pt. 2, p. 43), which is surely congeneric. And the separation from megalospheric *spectabilis*, even of *B. eocenica* Cushman and Barksdale, lately recorded by Parr from the West Australian Eocene, does not seem at all sure. A form quite like the Moeraki specimens, and also *spectabilis*, has been figured by Nuttall (*Journ. Pal.*, vol. 9, pt. 2, p. 125) from the Eocene of Venezuela.

Since this was written I had an opportunity to collect samples from two further bentonitic surface outcrops; 5392 (grey shale directly below basal Wheao conglomerate, Mangatu River) and 5391

(red shale below road level, Armstrong road, Waitangi district). Besides the usual facies background of such forms as *Haplophragmoides coronata*, *Rhabdammina* and *Hyperammmina* fragments, *Glomospira corona*, *Cyclammmina*, *Ammodiscus*, etc., *Bolivinospectabilis* and *Rzehakina* occur in both, though the latter is rare in 5392; an important addition in both is a number of calcareous species, which are too indefinite to refer positively at present to Cretaceous or Eocene, but which are not the well-core species, and show that the faunal differences are not just due to leaching out of the limy forms. One surface outcrop, however, has been seen (1015; Branch D of Red Shale Stream, Waitangi) which contained a Bortonian fauna as in the well cores; Eocene species of *Globorotalia*, *Pulvinulinella* and *Rotaliatina* were present, but no *Rzehakina* or *Bolivinospectabilis*. In the Puketoro Stream section is 1000 ft. of marl and red shale (3209) with a fauna poor in extent but undoubtedly equivalent to those of the well cores, and like them possessing *B. spectabilis*, but lacking *Rzehakina*; it lies definitely above 800 ft. of Rakauaroa argillite containing *Rzehakina* (3206). The existence of two red shale horizons thus seems very probable.

Two other localities yielded Tertiary faunas accompanied by *Rzehakina*. At Pouawa Dome (3286) a fauna was obtained from below another fauna which was Oligocene. The Oligocene fauna (3287) was slightly contaminated with specimens from the older bed; the latter had a predominately Wanstead fauna, but included three or four species such as *Rzehakina*, *B. spectabilis*, etc., which differed in preservation and were almost certainly derived from a still lower horizon in this complicated fault structure. The other locality (4019) was at Te Hua Stream, Waitangi, where the Wanstead fauna also showed *Rzehakina* and *B. spectabilis* but, as red shales were closely associated, it seems likely that again derivation occurred. Three further localities, 3284A (Pouawa Dome), 3290 (Whangara uplift), and 4013 (Waitangi uplift) yielded *Rzehakina* with calcareous species which are possibly Bortonian, but may be Cretaceous; they are all in disturbed areas, and are unlikely to yield pure faunas.

Apart then from the red shale question, it is evident that *Rzehakina* in New Zealand, especially when abundant, denotes Rakauaroa age (Whangai plus Tapuwaeroa ?), that it extends feebly to the underlying Raukumara, and that its appearances in overlying beds are all doubtful.

Outside of the Poverty Bay and Dannevirke areas *Rzehakina* is very rare. This may be owing to the absence of suitable lithologies. Yet the variety of facies in the Rakauaroa carrying abundant *Rzehakina* is considerable (conglomerates, sandstones, black shales, siliceous marls, bentonitic red shales, etc.). Some of these facies of suitable age certainly occur elsewhere in New Zealand, but the only other locality where an occurrence is known is 1283, near Silverdale, North Auckland. Here it is not uncommon and genuinely part of the fauna, which comes from a hydraulic limestone area and though that formation is Wanstead Eocene, it seems to be from an underlying Cretaceous horizon. The rest of the fauna is rather similar

to that of the *Rzehakina* red shales. In the large undoubted Wanstead faunas from the Pahi greensands and associated marls there is no trace of this genus, though the lithology appears very suitable; a deceptively similar poorly preserved form does occur, but it is evidently calcareous and probably a *Massilina*.

The above discussion relates to the species *epigona*; the genus itself, as a related form, *R. venezuelana* Hedberg (1937, p. 669), has been recorded from well up in the Tertiary; it is not unlike the thinner form of *epigona* already mentioned.

Genus HANTKENINA Cushman, 1924.

Hantkenina australis n.sp. (Plate 69, fig. 5).

A fully satisfactory description of this species cannot yet be given, as no well preserved, unbroken examples have yet been found. Though it occurs at a number of localities, it is generally so rare and fragile that a composite description must be drawn up from a number of specimens. The genus is, however, of such interest and importance that the record is made in spite of this.

The species is best described by comparison with *H. alabamensis*, the genotype, which it most nearly resembles. It has similarly compressed chambers but the sutural gutters are deeper and more marked. No examples have been seen with other than five chambers. The spine, as in *alabamensis*, is directly adjacent to the next suture (not as in *mexicana* and its allies quite distant from it); it is of about the same relative length when unbroken (as long as or longer than the distance from its base to the umbilicus) but instead of being practically straight as in *alabamensis*, it usually has a decided backward curve. A notable difference is that the succeeding chamber begins at the base of the spine at the same level as the previous one and does not start some distance up the spine, as is usual in *alabamensis*. The aperture is similar to that figured by Cushman (1924, p. 3) but is narrower and the basal wings are distinctly less spread, diverging at less than 90° , instead of considerably more.

The figured specimen was the best then available and is from Waitangi No. 2 well, 1560 feet. It has the surface badly preserved, has evidently suffered distortion, shows the chambers much too swollen and the spines broken, though the other details mentioned are the same. It measures 0.6 mm. in diameter (without spines) and 0.3 mm. in thickness.

The type (which will be figured later) has been chosen from the Hampden section, locality 5179B ($1\frac{1}{4}$ miles North of Kakaho Creek, upper blue clays, about 5 feet below the top)—an Upper Bortonian horizon. Five damaged but uniform specimens were found showing some perfect spines and a highly polished surface, minutely but distinctly perforate.

This species appears to be limited to the Upper Bortonian. Besides the two localities mentioned, it occurs at 3310 (Pahi marl, with *Zeauvigerina*), 5319 (Mangaotero S.E. Survey District, 1 mile .31 chains at 180° from trig U).

The Eocene species recorded from Mexico by Nuttall (1930, p. 272) have little similarity to the New Zealand form, with the possible exception of *H. longispina*, but this has a more open umbilicus, a lobulate periphery and a spine, though of similar length, not quite adjacent to the following suture.

Genus *ROTALIATINA* Cushman, 1925.

Though this has not previously been recorded from New Zealand, a typical species has been known for many years, under a wrong generic location. This is *Rotalia sulcigera* Stache, 1864 (*Reise der Novara*, Pal. vol. 1, page 275, plate 24, figs. 25a, b, c, d), of which the next described species *Rotalia naticoides* Stache (*l.c.* page 276, plate 24, figs. 26a, b, c, d) is an exact synonym. Stache's idealised and erroneous figuring of the sculpture and aperture has been responsible for subsequent confusion and inability to locate this common New Zealand species. Chapman, as evidenced by his slides, did not understand it and identified examples as *Cassidulina* and *Gyroldina*; in his New Zealand Bulletin he was unable to synonymise the names and retained them both as species of *Rotalia* of the *soldanii* type.

In the plentiful faunas that have now been examined from the Whaingaroa and equivalent series this shell is only occasionally absent and is usually quite common. Very fine specimens have been observed abundantly in the West Coast Point Elizabeth beds. Indeed, throughout the Ototaran sequence in quite varied lithologies this is a striking index fossil. It is absent, however, from such muddy and glauconitic deposits as Wharekuri and Chatton; but its occurrence in argillaceous glauconites elsewhere indicates that this is probably an age not a facies absence.

The species is not confined to the Ototaran, but also occurs, usually much more rarely, throughout the Eocene, at least down to the lower Bortonian. Small specimens are fairly frequent in Waitangi No. 1 well, cores 9 to 16. It is also present as large typical specimens in the Cheviot chalk marls at the base of the Amuri limestone (with an upper Bortonian fauna) and at Pouawa Dome, Poverty Bay (with a lower Bortonian fauna).

Its upper range is, however, strictly limited to the Ototaran and, though abundant in the upper parts of this formation, it has never been seen in hundreds of samples from the overlying Hutchinsonian and later beds; it has not even been found so far in the intervening Duntroonian and Waitakian stages. It is thus an excellent marker for the Oligocene and Ototaran when associated with post-Eocene elements (certain species of *Globigerina*, *Cibicides*, *Uvigerina*, etc.). Its occurrence, sometimes in abundance, at several localities in the Poverty Bay "Maungatapere" formation is part of the definite evidence for referring this stage to the Upper Ototaran (middle Oligocene). The Te Kuiti and Cobden limestones are so hard that only poor faunas can be obtained from them, but large specimens of *Rotaliatina sulcigera* are almost always present in the latter, but disappear in the grading beds above it.

This seems a suitable place to point out and correct an error regarding the Whaingaroa formation which has been world-wide ever since Stache described its fauna in 1864. Every subsequent author seems to have accepted without question his dictum as to its Eocene age. Cushman and Dusenbury, for example (1934, page 52), identified several Eocene Californian species with these supposedly Eocene New Zealand forms; several other workers have made similar comparisons and as late as 1937 Cushman and Parker (1937, page 66) took the age of topotypic Whaingaroa material as Eocene. Even in Australia this opinion has been prevalent; Chapman, with little relevant material, quoted Upper Eocene in his New Zealand Bulletin, and Parr and Collins (1937, pp. 190-211) quite recently discussed the Whaingaroa Polymorphinidae in terms of this age. In a later note, quoted in a paper by Bartrum (1937, p. 436), Parr has been the only writer to amend this conclusion and suggest a Lower Oligocene age. In 1933 I had written him stratigraphic notes on the succession in Poverty Bay, pointing out that much Tertiary still underlay beds coeval with the Whaingaroa, and his examination of a definite Eocene fauna from North Auckland made him realise that Stache's conclusions must be wrong. Stache's error was pardonable at the time, as he had no New Zealand comparative material and no knowledge of the stratigraphic column; it is only by intensive comparison with standard sections from many places in our Lower Tertiary that the Whaingaroa can be accurately placed. It is, as a matter of fact, Upper Ototaran, which is probably Middle Oligocene. Well defined faunas of the underlying Waiarekan and Lower Ototaran and the overlying Duntroonian and Waitakian (all stages of the Oligocene) are known in sequence at several localities, and the relation of the Whaingaroa fauna to the Eocene is but slight. The evidence for all this will be elaborated elsewhere—but the current misconception of the "Novara" fauna should be rectified.

The species *Rotaliatina sulcigera* (Stache) (plate 69, figs. 6, 7) is an extremely variable one in size, shape and height of spire, but has a general strong resemblance to *mexicana*, the genotype. This was from the lower Oligocene Alazan shale. Nuttall (1930, p. 272) has recorded it also as common in the upper Eocene Chapapote and rare in the middle Eocene Guayabal. This roughly corresponds to its New Zealand range. The apertural and sculptural characters appear much the same in the two species, but the New Zealand form is readily distinguishable by its more numerous chambers, having almost always nine (very occasionally eight to ten), instead of seven in a whorl.

Besides the Eocene and Oligocene forms, a species has recently been described from the Pliocene of West Java. This is *R. globosa*, Yabe and Asano (see 1937, page 124, plate 19, fig. 7). The authors remark that "This is a large species . . . the raised and granulated sutures are of peculiar type . . ." The size—about 2 mm.—is in fact enormous for the genus and the whole appearance of this Pliocene form shows plainly that it is derived from typical Javan species of *Rotalia*, such as *schroeteriana* P and J., and especially *alveiformis* Thalmann. It is really a form of the latter in which the

dorsal surface has become excessively raised and the base has descended, just as true *Rotaliatina* is a development along similar lines from *Gyroidina*. These differences in each case may seem slight, but go hand in hand with such obvious constancy and much more limited stratigraphic range that generic distinction is fully warranted. Apart from pronounced sculptural and size differences, *globosa* shows its distinction from *Rotaliatina* proper in its aperture, which is not the long, narrow *Gyroidina* slit, but is much more concentrated and open basally, as in the species of *Rotalia* mentioned. It is also non-umbilicate, as they are, while an umbilicus is one of the generic features of *Rotaliatina* and *Gyroidina*. The discontinuous record of the lineage would itself arouse suspicion, for true *Rotaliatina* apparently died out in the Oligocene, and the present case is evidently only another of the many examples of convergence. The Javan shell merits separation for the same reason as its earlier prototype and I accordingly propose the new genus *Asanoina*, with genotype *Rotaliatina globosa* Yabe and Asano.

An attempt was at first made to separate the New Zealand Eocene forms specifically but this was found to be impossible. All variations in size, shape of shell and chambers, height of spire, formation of apertural face and umbilical area found in the Oligocene formations can be matched at different localities in the Eocene and no practical discrimination can be made. The nearest actual specimens to Stache's figures are from locality 5231 (Waitetuna Estuary, 1 mile North of junction with main Raglan Road, 15 chains past limestone outcrop); these will be figured in a later paper. Figures 7a, b on Plate 69 are from Upper Ototaran specimens coeval with Stache's (locality 1242, Awakino River, marls below limestone on road 7 miles up river from village); figures 6a, b are from Upper Bortonian specimens from Waitangi No. 1 well, core 9.

Genus ZEAUVIGERINA n.gen.

Genotype *Z. zelandica*, n.sp.

Genus similar to *Eouvigerina* in size, biserial arrangement of most chambers and spout-like uvigerine aperture, but differing in first and last stages. The early chambers show not the slightest trace, even in the microspheric form, of spiroleptine coiling; the final chambers have no tendency to become irregularly triserial, the whole test being regularly bolivine throughout.

The general similarities to *Eouvigerina* (especially of the *aspera* and *gracilis* type, which have somewhat the same ornament) are so marked that close relationship must surely exist. If so, the elision of the theoretical coiled early chambers and the more settled and compact development throughout is probably due to the later appearance in time of this genus, *Eouvigerina* proper being an Upper Cretaceous form, while the New Zealand development is Upper Middle Eocene.

Zeauvigerina zelandica n.sp. (Plate 69, figs. 4a, b).

Test minute, even for the genus. Microspheric form larger, fairly regularly and acutely tapering, about eight chambers on each side and a small distinct proloculum, perfectly terminal and with no trace

of coiling. Megalospheric form shorter and less acute, with a tendency towards a change in the angle of tapering on one side at lower third, about six chambers on each side. Greatest width usually across last two chambers, but sometimes the sides below this almost sub-parallel. Considerable variation in outline and proportions. Early chambers usually considerably compressed in microspheric form, of equal inflation with the later ones in megalospheric. Adult chambers sub-globular, somewhat compressed from front to back, and closely knit at sutures, which are never more than shallow grooves and frequently almost obscured by ornament; they are not quite horizontal, but the angle is slight; a similar medial, undulating, shallow groove where chambers meet. There is never any trace of separation of the later chambers as in *Eouvigerina gracilis* Cushman. Final chambers not triserial, the whole structure of the shell being bolivine. Aperture rising abruptly from ultimate chamber where it meets penultimate, medial in position, a relatively stout and large tube with a fairly broad, phialine lip, sometimes very short or obscurely developed and occasionally very long and some part of it bent out of line of shell. Whole surface regularly and minutely studded with very fine papillae producing a roughened but glistening surface; sutures smoother and neck when long occasionally with last part smooth, but the papillae usually run right up to it.

Length 0.27 mm.; breadth 0.175 mm.; thickness half to two-thirds width.

These are the dimensions of the figured specimen, which is from locality 3310 (greasy marl, interbedded with greensand, 1 mile North-west of Pahi, Paparoa Arm, Matakoho Survey District). Since the figure (which gives quite a fair idea of the species) was drawn, better preserved specimens have been found from a locality where the sequence of beds is also much clearer. The holotype is accordingly taken from locality 5300 (Moeraki N.E. Survey District, 1 mile at 29° from trig E, "marly clay" of McKay), and will be figured in a later paper. The latter locality is the highest of a sequence of beds—the Hampden or Kakahoian glauconitic marls—all definitely Bortonian (Eocene). This sequence can be subdivided but *Zeuuvigerina* has not been found in the middle or lower parts. Also, in numerous other localities it occurs always associated with upper Bortonian species. It can be taken, therefore, as a good index of Upper Middle Eocene age, as distinct from the lower Bortonian, which is probably still middle Eocene.

The species is a characteristic one of the Wanstead horizon and occurs at numerous localities of this age in the Dannevirke and adjoining districts. It is also present in some of the chalk marls at the base of the Amuri limestone (e.g., Hurunui Mouth, left bank of river, first outcrop upstream from mouth) and incidentally proves the whole of the Amuri limestone in this area to be Tertiary and not older than Upper Eocene. It is again present at several places in the Te Hua marls of the Waitangi fault area and coeval beds in the Poverty Bay district, which are thus definitely referable to the Bortonian and cannot be Cretaceous in age.

NEW NAMES PROPOSED.

Generic:—

Zeauvigerina n.gen. (Fam. Heteroheliciidae). Genotype: *Z. zelandica* n.sp. (Upper Middle Eocene).

Asanoina n.gen. (Fam. Rotaliidae). Genotype: *Rotaliatina globosa* Yabe and Asano (Pliocene).

Specific:—

Hantkenina australis n.sp. (Upper Middle Eocene).

Zeauvigerina zelandica n.sp. (Upper Middle Eocene).

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The Relation Between the Major Islands of New Zealand (with a Bibliography).

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INTRODUCTION.

THE two major islands of New Zealand, each 500 miles long, are separated by a strait only fifteen miles wide. Besides the physical dislocation there is also an abrupt geologic break and, at first sight, there appears to be little relation between several of the formations on either side. On the other hand there is apparently little biologic discontinuity; indeed, none has been described in the flora, both sides being assigned to the same botanical province by Cockayne. Detailed zoologic evidence is not yet available but its general tenor is the same, indicating connection in the not too distant past.

Under the circumstances, it is not surprising that very diverse attempts have been made to explain the origin of this strait. The hypotheses so far put forward may be grouped into three classes, as follows:

Class A.—*General Subsidence Hypotheses.*

Crawford, Hutton.

Class B.—*Vertical Block-faulting Hypotheses.*

Hochstetter (2nd hypothesis);

Suess; Cotton.

Class C.—*Lateral Displacement Hypotheses.*

Hochstetter (1st hypothesis);

Park; Hobbs; Present hypothesis.

We may review briefly the opinions of the above authors:

Class A.—General Subsidence.

J. C. Crawford, in a series of publications (see Bibliography at end of paper), conceived of a former extensive river system flowing through the Cook Strait region from north-west to south-east. To this, many of the main river systems of the present day were tributary. Crawford was of opinion that a considerable subsidence dismembered the valley system, drowned the strait and formed both Wellington Harbour (according to Crawford previously a lake) and the Marlborough Sounds. One of the main difficulties encountered by this hypothesis is the absence of land to the north-west, whence the ancestral, hypothetical river was supposed to flow. No evidence whatever has been adduced to show that such a land area formerly existed, and, as the present Cook Strait coast is, with local exceptions, definitely of an emergent type, bordered by coastal plains and marine

terraces rising to hundreds of feet above sea-level, we must conclude that the former existence of such land in the present orogenic cycle is extremely improbable.

F. W. Hutton (1871, p. 393; 1899, p. 178) stated that: "An elevation of 500 feet would obliterate Cook Strait" and considered that it had been formed by more or less general subsidence. Hutton's work is less detailed than that of Crawford and adds but little to the Wellington geologist's views.

C. A. Cotton (1918, p. 324), discussing the origin of Cook Strait, has regarded the subsidence theories as inadequate because they require a downward movement for which there is no evidence, and are opposed to the clear evidence of uplift displayed along the present coast.

Class B.—Vertical Movement.

The three protagonists of this class of hypothesis are: Hochstetter (2nd hypothesis); E. Suess, who accepted Hochstetter's account; and Cotton.

F. von Hochstetter (1864B, p. xlv) expressed his later views on the origin of Cook Strait as follows: "Indem aber das Land durch Hebung, durch Anschwemmung, und durch Hervorbrechen der Vulcane einen nicht unbedeutenden Zuwachs erhielt, versanken andere Theile gleichzeitig in die Tiefe. Einen solchen Ereignisse mag die Bildung der Cooks und Foveaux Strasse ihren Ursprung verdanken" (When the land had acquired a not inconsiderable increase in size through elevation, through alluvial deposit and through the ejectamenta of volcanoes, another part sank into the deep sea. Such an event, a sunken origin, caused the formation of Cook and Foxeaux Straits.). Later (p. 263) he wrote: "Der Senkung des Landes während der Driftperiode schriebe ich die Bildung der Cooks und Foveaux Strasse zu."

Hochstetter believed that the main mountain range of the North Island, which is continuous from East Cape to Wellington, was represented in the South Island by the Kaikoura Mountains between the east coast and the Awatere River.

This interpretation was accepted by Suess who, in his mighty work "The Face of the Earth" (vol. II, p. 144), wrote: "Hochstetter had already suspected that Cook Strait and Foveaux Strait, which separate the three islands, were due to the subsidence of mountain blocks; he was also aware that the mountain chain which follows the east coast of the North Island from East Cape to Wellington is continued on the other side of Cook Strait between the east coast of South Island and the River Awatere, and that this continuation lies to the east, outside the trend of the principal chain."

Marshall (1911, p. 57) has put the same statement in another way: "One looks in vain for a mountain range in the North Island which might be regarded as a continuation of the dominant range of the South," and Cotton (1916, p. 317): "In the North Island the absence of a continuation of the main mountain range—the

Southern Alps—of the South Island has often been remarked upon and the statements of Hutton and Suess on the subject are perhaps correctly interpreted as indicating their belief that the north-eastern continuation of the Alpine range has subsided independently. In view, however, of the late date of the movements to which the South Island ranges owe their present height, and in view also of the presence in the North Island opposite those ranges of Tertiary rocks of greater age than the orogenic movements, it would be more correct to say that this portion of the North Island has merely not been uplifted to the same extent as the South Island."

Obviously the distribution of the various rock formations and mountain ranges was causing these theorists a difficulty which became more apparent as time went on. In the latest attempt to establish the hypothesis, Cotton (1918, p. 325) accepted the general idea as correct; but, realizing that the age of some of the rocks on the margins of the Strait required that its formation should be geologically very recent, he substituted for the "subsidence of earth-blocks" the conception of "earth-blocks which had failed to rise" with the neighbouring areas. A further difficulty, however, arose (noted by Cotton in the case of the Moas) in that the nature of the fauna and flora on the two islands near the strait requires that they should, at one time, have been joined. This he overcame by adopting the tentative hypothesis of connection after the major orogenic movements with subsequent separation as a result of the subsidence of blocks, "possibly contemporaneous with the partial subsidence of an adjacent portion of the South Island" (the Marlborough Sounds). This statement contradicts his original idea of earth-blocks which failed to rise, and tends to revert to the standpoint of Hochstetter, which he had already recognised as inadequate.

As will be seen later, these hypotheses fail to account satisfactorily for many of the facts of geologic structure of the neighbouring land areas which are now known. The recognition (King, 1937, p. 44) of the vertical displacements of Marlborough as expressions of a deep-seated compression of the New Zealand earth-ridge now gives ample scope for the concept of a lateral thrust of the island masses, permits their earlier connection, and thus fits the facts of biologic distribution more closely than will any combination of purely vertical movements besides bringing into harmony the present staggered eastern coasts, the offset mountain ranges and the geology of Marlborough and Wairarapa. The combined weight of the opinions of the authorities cited has, however, tended to discourage the discussion of the problem from other viewpoints.

Class C.—Lateral Displacement (Dislocation).

Though three geologists have already proposed theories of this type none has adequately discussed any aspect of the matter other than the obvious fact that the coastlines and mountain ranges of the islands are not continuous but are offset at Cook Strait. As the present writer presents an hypothesis of this type their pronouncements will here be quoted in full:

F. von Hochstetter (1864, p. 106) expressed his first hypothesis as follows: "In the present map of New Zealand the integrity of this backbone (the main mountain range) is broken at Cook's Straits, and a closer inspection will show that there has been not only a simple break of continuity, but a lateral dislocation," and later: "whilst the Northern island seems to have remained stationary, some gigantic force has pressed the great mass of the Middle (South) Island to the westward."

J. Park (1910, p. 262) wrote: "The abrupt termination of the Mesozoic rocks at Cape Terawhiti, and the presence of the semi-metamorphic Kakanui on the opposite side of Cook Strait would indicate that not only does a powerful dislocation separate the two islands, but that the North Island has been thrust eastward some distance relatively to the South Island."

W. H. Hobbs (1923, p. 752): "The testimony of the geological map prepared by the New Zealand Geological Survey is that the western margin of the Hokonui beds is offset to the eastward by about fifty miles as it crosses the Strait to the North Island, and this is about the same distance as the eastern coasts are offset."

C. A. Cotton (1918, p. 324) wrote in criticism: "Of this relative movement of some fifty miles there is no satisfactory field evidence and the theory has nothing to recommend it."

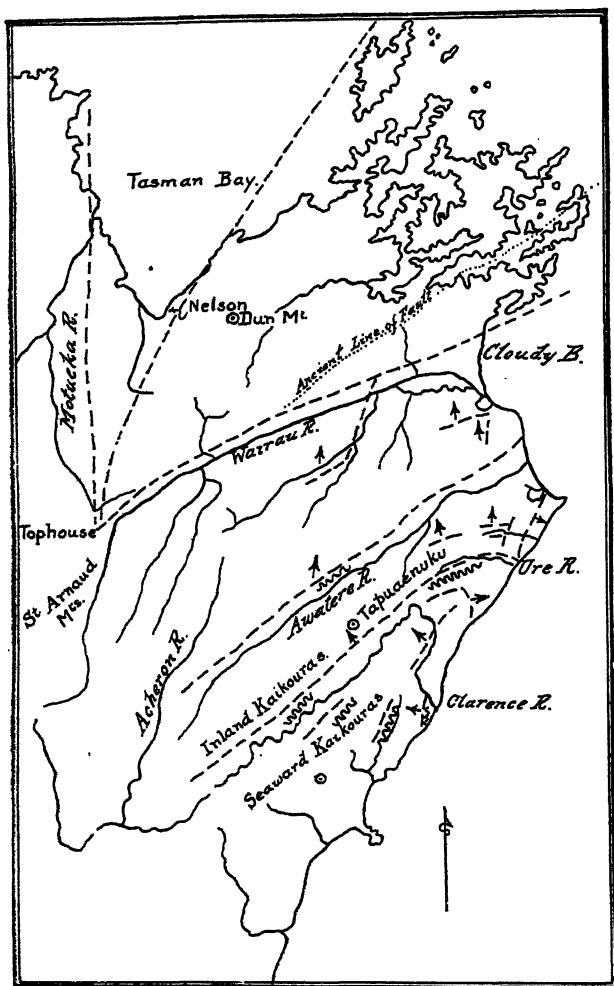
Beyond these single utterances, unsupported by detailed evidence, no one has offered any further contribution to the subject of lateral dislocation.

OUTLINE OF PRESENT HYPOTHESIS.

The writer's hypothesis is that the central segment of New Zealand has been subjected to intense shearing stress associated with the later stages of the compression which formed the New Zealand mountain ranges. This has resulted in the rupture of once-continuous geological and topographical features and the development of a definite offsetting between the North and South Islands.

The simple conception of former unity by bringing the islands into line, fostered by Hochstetter (but later abandoned by him), Park and Hobbs fails, however, to fit almost any of the facts of geologic structure and a more elaborate reassembly must be undertaken.

In the writer's *reconstruction*, the North Island is moved to the west alongside the eastern margin of the Marlborough Sounds. This latter area is considered to be a more or less distinct earth-block bounded by two major faults which, continued southward, meet near Tophouse (Fig. 1). This triangular segment is regarded as having formerly occupied a position roughly where Tasman Bay now lies and to have swung to the east about the southern apex with the North Island in the earlier stages of the dislocation (Fig. 2). In the actual deformation, of course, the movements took place in the reverse order



----- Faults. ~~~~~ Synclines.

FIG. 1.—Structure Map of North-Eastern Marlborough. Arrows indicate directions in which the earth-blocks are tilted.

and direction to that given above, i.e., the southern portion of the united islands moved to the west, the Marlborough Sounds block tending to stay with the North Island and a split developing between it and the mountainous country of North-west Nelson. When further movement of the South Island relative to the North occurred, the Marlborough Sounds block was also carried to the west, opening up a new rift which now forms Cook Strait.*

* The later section entitled "Summary" may now be consulted if so desired. (P. 561.)

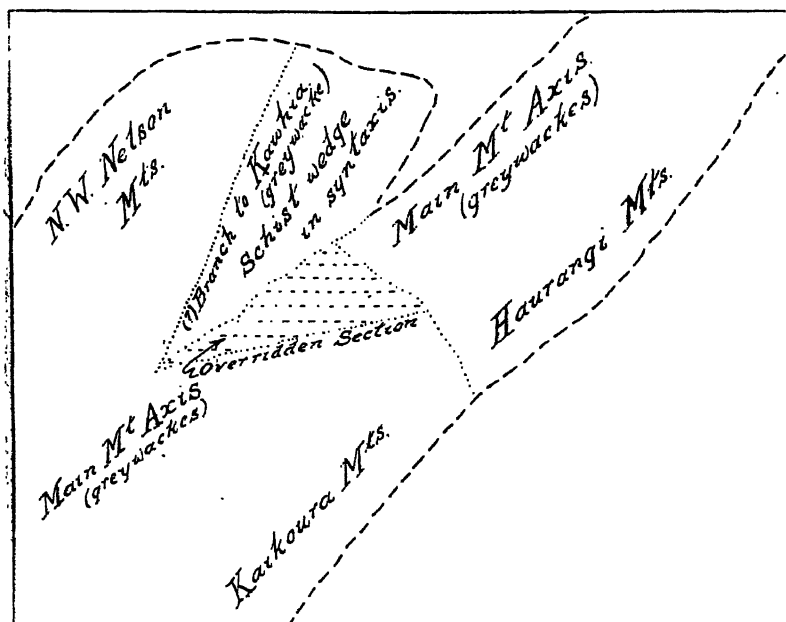


FIG. 2—Stages in the formation of Cook Strait.

STAGE 1—The two islands united with their Main Axes and secondary mountains in line. The section which is later overridden during the formation of Cook Strait is ruled.

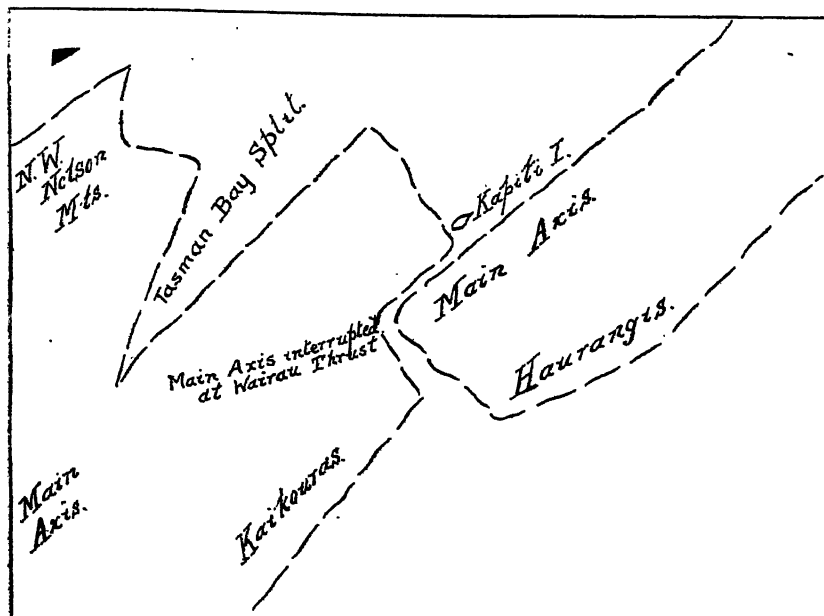


FIG. 2, STAGE 2—The South Island has moved westward faster than the North, causing the development of the Tasman Bay Split and the overriding of material by the Marlborough Sounds Block along the Wairau fault. Mountain ranges no longer co-axial in the two islands.

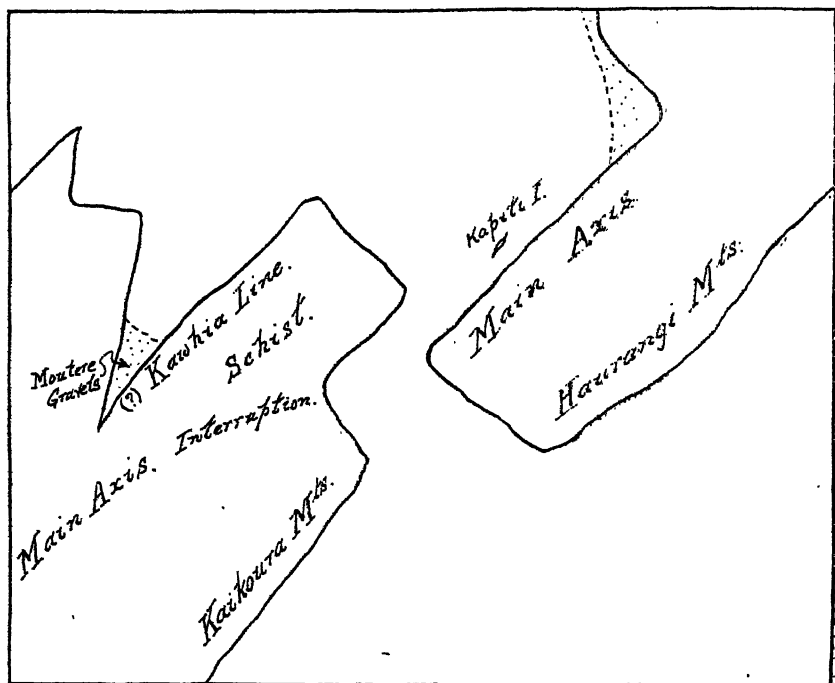


FIG. 2, STAGE 3—Further migration of the South Island has resulted in the final separation of the islands. Infilling by the Moutere Gravels and Horowhenua deposits is occurring. Later growth of these deposits, with the tectonic movements resulting in the formation of Port Nicholson, Palliser Bay, and the Marlborough Sounds, produces Stage 4, which may be examined on any map of the Cook Strait region.

THE EVIDENCE.

Evidence has been collected copiously along many lines and was set out in full in a manuscript of which this paper is an abridgment. Owing to limitation of space imposed upon contributions to this Journal, it is not possible here to present this evidence in full. The points put forward are merely a selection from the larger work and no attempt is made to treat any line of evidence fully. Preference has been given somewhat arbitrarily to less known or more interesting topics bearing on the general argument.

PRESENT SHORELINE.

Studies by Cotton (1921) and the writer (1930) have demonstrated clearly that the North Island Coast is fringed by uplifted marine terraces which are warped and tilted not only with respect to present sea-level but also with regard to one another.

Palliser Bay may be regarded as typical. Superficially this appears to be a simple fault-angle depression, the western boundary coinciding (with small allowance for marine erosion) with the Rimutaka fault-scarp which is traceable along the Wairarapa Valley for sixty miles from the opening of the Bay (Ongley, 1935, p. 3). The raised marine platforms along the sides and head of the Bay show clearly, however, that considerable warping has also taken place, the axis of which passes centrally up the Bay through Lake Onoke and Lake Wairarapa.



FIG 3—Representation of the deformation undergone by two of the ancient strandlines of Cook Strait.

The terraces of Palliser Bay, moreover, exhibit a tilt to the North so that, if we may regard the cut marine bench and the covering deposits as we would a normal sequence of stratified rocks, we would define their formation as in the form of a broad asymmetrical syncline, one limb of which is partly transected by a fault, and which pitches gently to the north. That this movement has taken place progressively is shown by the fact that the older terraces are more strongly warped than the younger, the relation generally being similar to that of the older and younger terraces at Cape Terawhiti and Tongue Point (see King, 1930, pp. 500-2).

The combined warping and northward tilt are, no doubt, primarily responsible for the depressions occupied by Lakes Onoke and Wairarapa.

These features indicate the former presence of forces of compression in the Cook Strait region, though they represent probably only the final results of the application of such forces. The writer believes that one of the earlier results was the formation of Cook Strait itself.

Attention may also be drawn to the Marlborough Sounds. This rias-system has been produced by the partial drowning of a land surface of strong relief with the dismembering of its mature valley-systems. Cotton (1913, p. 318) has estimated the amount of drowning as 250-300ft. The fact that it is physiographically so distinct from any other area near Cook Strait and that it is bounded to east and west by major fractures indicates that it has had a history which differs considerably from that of neighbouring areas (Figs. 1, 4). This fundamental difference has not been sufficiently taken into consideration in previous theories bearing on Cook Strait.

Note on the Origin of the Cook Strait Margins.

There can be no doubt that the outlines of Cook Strait are determined by fractures. The north-west side of Wellington Harbour, the west side of Palliser Bay, the east and west coasts of the Marlborough Sounds Block and the western side of Tasman Bay are all governed by the occurrence of prodigious faults, which can be traced inland. Practically all the remaining coasts yield, on close scrutiny, evidence of having formerly belonged to this type. Several have been discussed by Cotton in a classic paper (1916, pp. 20-47) in which the criteria to be applied were set forth. The application of these criteria to the other steep coasts of Cook Strait* reveals that many of them, too, originated as fault-coasts. The southern coast of the North Island, the western coast from Cape Terawhiti to

* In some cases ancient coasts now bordered by younger deposits.

Paekakariki continued thence along the ancient shoreline back of the Horowhenua Lowland to the Manawatu, the coast south of Cape Campbell and the eastern coast of the North Island all yield presumptive evidence indicating their origin along earth-fractures.

The recognition of fault-coasts when marine erosion and later earth-movements have modified the original form is a matter of no inconsiderable difficulty, and Professor Cotton's contribution to the history of Cook Strait on these lines is of fundamental importance.

SUBMARINE EVIDENCE.

Admiralty Chart No. 695 is practically the only source of information on the present form of the floor of Cook Strait. A few extra soundings have been obtained from various sources; but, on the whole, study of the present submarine topography has yielded little of value to our discussion.

The following points have been established:

(a) There is no continuous channel deeper than 100 fathoms through the strait.

(b) In spite of strong tidal currents, the material on the bottom appears to be largely of local origin, e.g., the Wellington side has a rock and gravel bottom, as also has the north-east part of the Sounds district, Cloudy Bay on the other hand, is shallower and has fine sand everywhere recorded.

(c) A number of "holes" or deep basins exist towards the northern side. These are not continuous, though to some extent arranged in lines. The deepest of these descends from 97 faths. to 414 faths. in a distance of one mile. These troughs are evidently associated with submarine faults, the presence of which is further indicated by not infrequent earthquake shocks centred in Cook Strait.

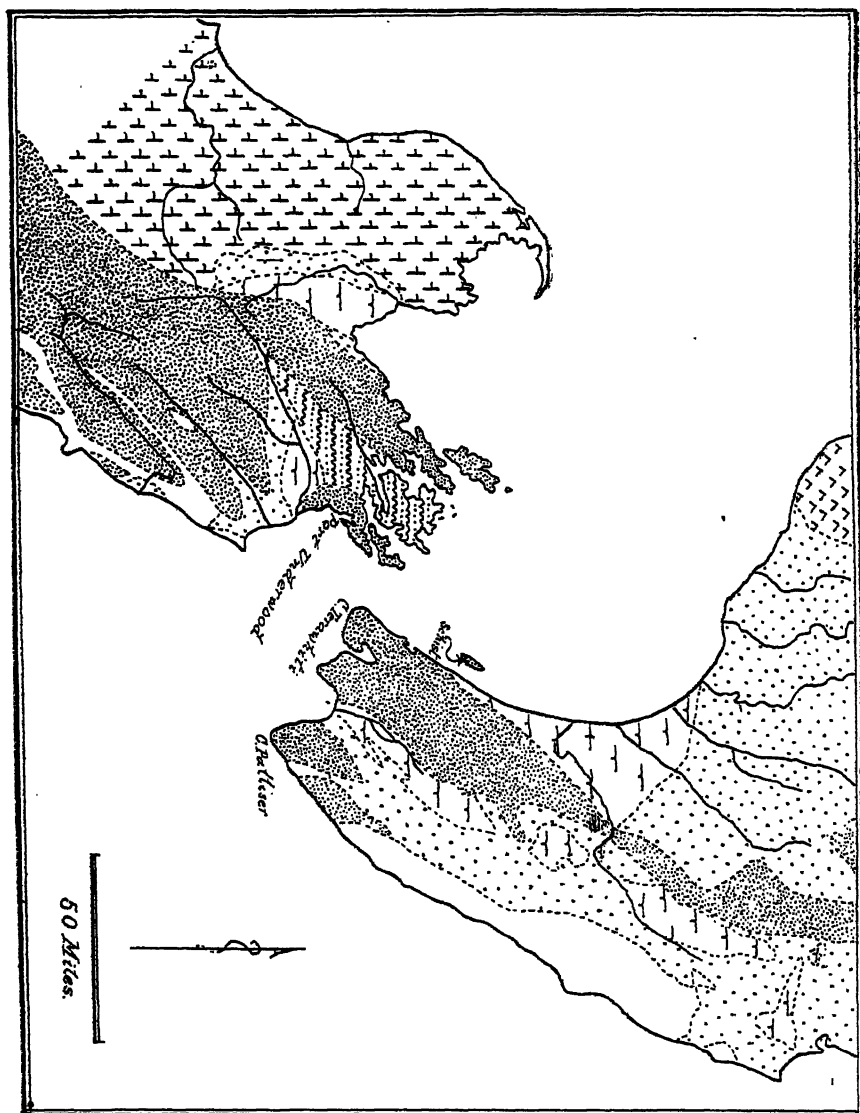
If, according to the present hypothesis, the North Island is considered to have occupied a position such that Cape Terawhiti lay in the neighbourhood of Port Underwood, then the apparent difficulty of shallow water (less than 50 feet) in Cloudy Bay is readily met by the fact that all soundings show dark sand, submarine delta infilling from the Wairau and Awatere rivers. Of the original depth of this sector there is no indication.

STRATIGRAPHIC EVIDENCE.*

With the exception of North-west Nelson, hardly any district investigated by the present Geological Survey of New Zealand reaches the shores of Cook Strait. Moreover, the work published refers to just those areas which are of least value to the present discussion.

In the absence of systematic surveys by official parties, therefore, much routine work devolved upon the writer. Part of what was done has been published (1932, 1933, 1934, 1936, 1937); some was carried out in too disconnected a form to be suitable for publication

* Here again, limitation of space forbids any account beyond notes on one or two of the formations more intimately concerned with the argument, preference being given to less known occurrences.










1.  Marlborough Schist. 2.  M. W. Nelson Complex.
3.  Mesozoic (?) Greywackes. 4.  Marine Cretaceous.
5.  Marine Tertiary. 6.  M. Egmont Andesites.
7.  Quaternary (mainly).

FIG. 4—Geological Sketch Map of the Region bordering Cook Strait (modified from the Geological Survey Map published in 1921).

on regional grounds alone; but all that is at present required is a sufficient knowledge of the stratigraphy to permit matching of formations in the two islands. With this must go an understanding of the structure adequate for similar tectonic matching and explanation of the movements which have taken place.

The Moutere Gravels.

Much of the western rampart of the Southern Alps is bordered by outwash plains of gravel, which probably vary considerably in age from place to place. Their equivalents in the Nelson District are the Moutere Gravels, a deposit of coarse conglomerate certainly exceeding 1000 ft. in thickness and possibly in excess of 2000 ft. (Hector, 1879, p. 37). These occupy the triangular area at the head of Tasman Bay up to the convergence of the North-west Nelson Mountains and the Spencer and St. Arnaud Ranges. On either side, between the gravels and the faults bounding the mountain ranges, a narrow strip or series of lenticular outcrops of somewhat older Tertiary strata occurs, the Jenkin's Hill beds of Nelson and the Glenhope beds of the western side.*

It is essential to the writer's hypothesis that the Moutere Gravel beds should be relatively young and occupy the rift formed by the westward migration of the North-west Nelson Complex of blocks in the first stage of the dislocation. Let us see what Henderson, the latest authority on the Moutere Gravels, says (1929, pp. 287-288): "The weathered Moutere Gravels occupy most of the floor of the Nelson graben from Tasman Bay to the St. Arnaud Range, mountains of quartzose greywacke. The gravels are mostly of the same rock and are in fact the piedmont deposits from the mountains of which this range forms a part; it should be noted that the highlands east and west of the graben are of quite different rocks and supplied but an insignificant amount to the gravels. These deposits, which, so far as known, are not folded or faulted, overlie the conglomerates, sands, clays, and lignites of the Glenhope series. The pebbles in the conglomerates of these latter beds are of the same igneous rocks that form the adjacent high country east and west of the graben. The Glenhope beds are upturned near the edges of the lowland and are there unconformable to the overlying Moutere gravels, but except near the bounding faults they lie flat and grade upward into the greywacke gravels."

A further statement by Henderson (p. 288), made without any consideration of extensive rift-opening, may also be quoted in support of our thesis: "The sea does not seem to have covered the area of the Nelson graben until late in Ototaran time, perhaps even till the Hutchinsonian. The beds of this transgression were tilted and raised above the sea before the valley plain deposits of the Glenhope series accumulated. These movements were probably the prelude of the Kaikoura orogeny, a deformation that culminated after Glenhope time and raised the mountain mass of which the St. Arnaud

* These latter are omitted to the north on Geological Survey Maps but have been identified there by the writer.

Range is a part. The Moutere Gravels, the piedmont deposits derived from the highlands then formed, are correlated with the Castlecliff beds, and the Glenhope beds with the Nukumarū beds."

A slightly different viewpoint reveals here an example of sedimentation in an opening rift, the formation of which began in the middle Tertiary, but was continued into the Pleistocene.

The Marlborough Sounds District.

Since the time of McKay's (1879, 1879B, 1890, 1890B) rapidly executed investigations, no geological research has been undertaken other than Cotton's physiographic study of the Tuamarina Valley (1913), Morgan's investigation of the occurrence of coal at Pictou (1921B, pp. 11-18) and Henderson's papers upon the gold deposits about Wakamarina (see 1935).

McKay showed that two main rock types are represented, each of which contains probably more than one series. The central mass, elongated north-east to south-west, is almost entirely schist. On this no petrological work whatever has been done and ignorance of the age, constitution and relations of the schist is profound. Certainly nothing short of a large-scale government geological survey with competent co-lateral petrological advice is likely to yield any adequate account of the Marlborough schist area. The writer, in the hurried period before his departure, endeavoured to ascertain some of the facts of structure; but the results are too disconnected for separate publication and did little more than lay bare the magnitude of the problems involved. The schist extends far to the south-westward as is indicated by Park's observations in the Spencer Mountains (1885, p. 357).

In the North Island, the only counterpart of the Marlborough schist is on Kapiti Island, some seven miles from the mainland (Ferrar, 1928, p. 314). Of this, only intensely weathered specimens are available which are useless for petrological examination and comparison with the Sounds material. This occurrence is of great importance to our argument.

Correlation.

In each island, the physiographic and stratigraphic backbone is composed of a system of alternating greywackes and argillites to which a Mesozoic age is usually assigned. West of the backbone, the correspondence of the Nelson rocks with those of Taranaki is, at first sight, poor; but closer inspection reveals evidence (Marshall and Murdoch, 1920, p. 118) that the shattered granite and Palaeozoics of North-west Nelson probably pass below Cook Strait and underlie the late Tertiary rocks of Taranaki.

Eastward of the backbone the match is surprisingly good. The Awatere beds correspond closely with the Tertiary rocks of Palliser Bay (King, 1934, pp. 12-13, 1936, p. 31; Thomson, 1919, pp. 281-282), and the Haurangi Mountain greywackes evidently belong to the Kaikoura Group. The latter do not reach Cook Strait owing to a torsional effect in the structure of the north-east corner of Marlborough, where, as the writer has already recorded (1934, p. 9), the

north-north-east trending structure of the Clarence district swings to the east at the Ure River. They are of the usual types; but differ from those of the Tararuas and the Marlborough Sounds in that they are seamed and shot through by a great variety of igneous rocks, including several acid and semi-acid types.

Igneous rocks, collected by McKay from the Haurangi Mountain region, were described by Sollas; but whether these were from outcrops or pebbles from conglomeratic bands the writer is not aware. The point need not affect the present discussion though it may be productive later of a close correlation with the Kaikoura Mountains of the South Island.

Along the east coast, north from Cape Palliser, the Amuri limestone crops out, probably the most characteristic rock of North Canterbury and Marlborough. With it is frequently associated the "Grey Marl" its invariable attendant in the South Island, while at places, also, it is underlain by greensand (e.g., south of Glenburn). This particular succession, Cretaceous greensand, Amuri limestone and "Grey Marl" is one which is extremely characteristic of the north-east region of the South Island, none more so, and its presence here is highly significant. Always these rocks are separated from the greywackes of the Haurangi Mountains by great faults, commonly of the reversed type, and McKay (1879, p. 82) records that a narrow strip of Miocene (Hurupi Creek) beds occur between the Amuri limestone and the mountain greywackes. This clearly indicates that the structures there are similar to those in the Kaikoura Mountains in the South Island (e.g., Middle Clarence Valley), and the occurrence must be regarded as of the highest importance.

STRUCTURAL EVIDENCE.

The proof for an hypothesis of this nature must rest largely on the elucidation and interpretation of the facts of structure. A close correlation of physiographic features may or may not exist on either side of the displacement; but, if the hypothesis is true, there should be some definite matching of geologic formations on either side (see previous section) and some co-ordinated structural scheme in the two related areas. The number of features which may be matched on either side depends upon the age of the tear and the presence of minor irregularities associated with the rifting, possibly none may form perfect counterparts; but, nevertheless, they should fit into some general scheme.

In the note on the stratigraphy of the contiguous portions of both islands, it was shewn that there is a definite similarity, particularly in the east, between the formations represented, which is rendered much more striking if it be admitted that the two islands did not always occupy their present relative positions.

This surface distribution of geological formations is governed wholly by the geological structure and, if the lithologic parallels so far pointed out are correct, a correspondence must also exist between the dislocations involved and the tectonic histories.

Elsewhere (1937), the writer has discussed the formation of the mountains of Marlborough, shewing that they owe their origin to a

deep-seated movement of compression. Those to the west are bounded, and separated range from range, by immense reversed faults dipping east. Those to the east, the Kaikouras, are separated in the same manner by fault angle valleys with mighty reversed faults heading to the west. The two systems meet near the Wairau fault which, though truly a scissor fault, is mainly of the Kaikoura type. West of it is a scar of schist, and to the east, the Tertiary sediments of the Wairau-Awatere district. In the North Island the western type of structure is certainly present north from Wellington; but the Rimutaka fault is of the eastern type, and the composition and structure of the Haurangi Mountains, as far as these are known, permits them to be called the Kaikourides of the North Island. Thus, not only do geological formations have a similar distribution; but also similar or corresponding structures.* As, however, the lateral dislocation is apparently later than the movements which gave rise to the present geological distribution, or was, perhaps, a final expression of them, it is to be anticipated that there will be distortions of major faults and trendlines in the immediate neighbourhood of the Strait.

These are shewn in North-eastern Marlborough where, as the writer has previously remarked (1934, p. 9), the faults bend from a north-north-east direction to the east (Fig. 1). Even the Great Clarence fault, transecting a previous overfold, is no exception. This may be interpreted as a drag effect, consequent on the dislocation, and caused more immediately by the fact that this segment of the South Island would be more closely in contact with the North Island than any other. Also, we have noted in our reconstruction (p. 548) that, during the relative movement of the South Island to the west, a segment of Nelson was left behind to form the stratigraphically and physiographically distinct block of the Marlborough Sounds. With farther straying of the South Island to the west, torsional structures have been developed in the north-east corner of Marlborough due to the resistance of the ancient rocks of the Marlborough Sounds block.

West of the main ranges is the relatively sunken area of Tasman Bay. With the triangular southern district infilled by Moutere gravels this is usually designated a graben, on the hypothesis here presented it is a split. The fault along the eastern margin is of the reversed type, that to the west has not yet been described. Observations by the writer indicate that only minor disturbance is shewn by the younger beds in the relatively downthrown area and this fracture may well be of the tension type.

A word of explanation may perhaps be offered regarding the absence of recent volcanic rocks along this assumed line of tension

* This is splendidly shewn not only by the presence of the Amuri limestone and "Grey Marl" on the coast north from Cape Palliser; but that, once more, their structure and relation to the greywacke masses resembles that normally shewn in the east coast region of the South Island. Features similar to those recently suggested by the writer in the Clarence area (1937), where thrusting and overfolding occur in the Amuri limestone and succeeding beds, may later be shewn to exist near Cape Palliser, when the present regional survey is extended to the south.

and along the eastern margin of the Marlborough Sounds block from Port Underwood to Tory Channel. These are the only areas involved in the Cook Strait movements wherein compression was not clearly in the ascendant. If, however, we regard the forces generating the whole related series of dislocations as due to a fundamental deep-seated compression then the difference lies only in a superficial layer or flake and no opportunity may have been provided for volcanism to reach the surface.

THE POSITIONS OF EARTHQUAKE FOCI.

Data assembled by Bastings and Hayes (1935, p. 310) regarding the distribution of earthquake shocks in different parts of New Zealand show that two areas are of far greater seismic frequency than others. These are the centre of the North Island and the Cook Strait-East Coast N.I. region. The record of the former is much enlarged by the thousand or so small, local shocks which occurred in the Taupo region in 1922. If these are neglected, as probably due to the rise of magma and other volcanic phases, Cook Strait, together with the East Coast of the North Island, assumes first rank in New Zealand as an area of tectonic disturbance. The East Coast seismicity is matched by a strongly active zone, roughly parallel, 200 miles to the east and separated from the North Island by a submarine trough (Henderson, 1932, p. 132). Both these zones are undoubtedly distinct earth-ridges at present in active process of rising from the ocean depths. Their seismicity is but a normal feature. The peak frequency of North-west Nelson, as displayed on the map of Bastings and Hayes, requires, however, a special explanation such as the lateral movement postulated here.

The study of earthquake *intensity* also bears out our thesis of recent and perhaps still-continuing movement in Cook Strait. Omitting the disastrous Napier Earthquake of February 3, 1931, the only areas in which shocks of an intensity 9-10 R.F. are known to have occurred are those in the contiguous portions of the islands, i.e., towards Cook Strait, in positions where the movements may conceivably be due to adjustments in conformity with the lateral movement which has taken place in that region.

Insufficient data upon the precise location of epicentres between the islands are yet available for the tracing of submarine faults and fractures, though in a recent communication (May, 1937) the Acting-Director, Dominion Observatory, informs me that, in the future, attention will be focussed more upon this point.

On the whole, Seismology, though it affords little detailed confirmation, supports a very recent origin for the fracture between the two islands and suggests that movements may be still in progress.

BOTANIC EVIDENCE.

The botanic evidence is very decisive and can be given without detail. Cockayne (1907B, p. 313; 1921, pp. 299, 303; 1926, pp. 19-20), who mapped the botanical provinces of New Zealand, demonstrated beyond doubt that these were entirely independent of Cook Strait. The province to which the southern Wellington district belongs passes

without appreciable change to the South Island, where it continues south as far as the Clarence River. Here it is sharply limited, latitude evidently exercising much more of a controlling influence than the presence of a fifteen-mile wide strait. The botanic provinces of central New Zealand are governed by two factors: latitude and altitude, and cross Cook Strait as though it was not present. This is strong presumptive evidence that, at the time when the plants apportioned out the land among themselves, the strait did not exist. It is unnecessary to give details of individual species, such are often misleading; but the pronouncement of Cockayne has been tested (by Allan) and found to be authoritative. One particular case which deserves special mention is Cockayne's record of some typically South Island plants on Kapiti Island (1907).

The contention may arise that the New Zealand flora is archaic, judged by world standards. Even so, it provides no obstacle to the application of the ordinary laws of distribution.

Late Pliocene and Pleistocene plant remains are little known in New Zealand: Oliver's account (1928) of the flora of the Waipaoa Series occupies an almost unique position in this respect.* Under these circumstances it is not yet possible to advance any contribution from sub-fossil botany.

MOLLUSCAN EVIDENCE.

The land mollusca have never been subjected to a thorough survey. The work of Hutton (1883, pp. 186-212) was very imperfect so far as the knowledge of distribution of species was concerned but indicated that, of a total of 116 species, "about one half were confined to the North Island, one quarter to the South Island and one quarter (was) common to both."

Since then the only work of any importance, apart from Suter's systematics, is that of Powell on the Paryphantidae (1930, pp. 17-56; 1932, pp. 155-162). As Powell points out, both the individuals and their eggs are too large for accidental transportation by birds or other chance means to occur, so that, as immersion in salt water is fatal to both snail and eggs, continuous land is necessary for their dispersal. He infers that the species, which are very restricted geographically, are of strictly local development and that "features such as mountain ranges, river systems and islands, have played and are still playing an important part in the segregation and evolution of species."†

Powell has drafted a map (1930, p. 20) showing the distribution of present day species and indicating their relationships. These are such, bearing in mind the apparent rapidity of evolution in this group to correspond with topographical details, as to demand unity

* Since these lines were penned, the same author has described a Pliocene flora near Dunedin (*T.R.S.N.Z.*, vol. 66).

† A remarkably similar case is presented by the Achatinellidae of the island of Oahu, in the Hawaiian group, where each valley supports its own particular species, the various species being derived from a common ancestor evenly distributed over the island before the carving of the valleys (Stearns and Vaksvik, 1935, p. 6).

of the two islands in the recent past. It would be interesting to know whether species of *Paryphanta* inhabit the Haurangi Mountain region and, if so, to what group they belong.

On the whole, the marine molluscan evidence is disappointing in view of the concentration of effort on this group in recent years. Moreover, not only are the relevant data scanty, but there seems small prospect of further work proving of value in a discussion of the relation between the two islands.

Insect Evidence.

No comprehensive account of the insect faunules has been written, so the writer made a survey, from published lists of species, of the Lepidoptera found in one island only. From this survey were expunged those species which have been collected only in regions remote from Cook Strait, leaving a small residue of species which occur only in one island and near the shores of the strait. The writer then endeavoured to ascertain whether these were species which would have been definitely located in their present districts in any case, e.g., confined by altitude, or whether the presence of the Strait had exerted a definite restriction on their distribution. Not being a trained entomologist he soon found himself in difficulties, the mountainous nature of the terrain offering considerable opposition to insect dispersal and yet not wholly forbidding it, while the felling of bush and the destruction of natural habitats introduced factors which were difficult to evaluate. Entomologists consulted were unable to make any final statement on the matter. At the same time the distribution of the Coleoptera was similarly treated; but with a like result, namely: that there are definite species inhabiting regions adjacent to the shores of Cook Strait in one island, but not passing over to the other, is certain; but whether their restriction is due to the prior presence of the Strait or to other natural controls is at present unknown.

Myers (1926), however, has made observations on the Heteroptera which are significant in the light of the present discussion. He records (p. 455) nineteen species from both islands, ten from the North Island only, and three from the South; but the most outstanding result of his work is the discovery that those North Island species which are found in the South Island extend only to the northern portion of that island and follow the plant distribution. Although about half the species occur on trees, it is unlikely that the change of botanical province will govern their distribution so closely as to confine them north of the 41st. parallel of latitude.

This similarity of distribution between two groups of organisms, neither of which is absolutely dependent on the other, is worthy of further investigation and points to the conclusion that they conform to an older order of things and that the formation of Cook Strait is a recent feature.

Various other groups were examined by the writer and it was found that, though in individual groups uncertainty may exist, the trend of the biologic evidence as a whole admits of no mistake. The plant distribution alone renders former closer connection of the two

islands imperative, and when this is taken in conjunction with the avian and molluscan (land) evidence one is forced to the conclusion that, compared with the fauna and flora in their existing distribution, Cook Strait is a relatively new feature. There can be no equivocation. The biologic evidence compels the adoption of an hypothesis which admits of the continuity of the two island masses at no very remote date.

SUMMARY.

We may now review the subject as a whole, and fit each portion of evidence into its correct place. We have seen the close connection which exists between geological features on each side of the strait, and the nature of the biologic evidence which calls for closer connection in the not too distant past. The question remains; how were the islands united? Mere shifting of one island into line with the other will not do, for then the Marlborough schist should outcrop in the Wellington area, an apparently insuperable barrier to such a reconstruction.

If, however, the South Island be brought eastward* so that the Terawhiti angle of the North Island fits into Cloudy Bay near Port Underwood, the greywacke ranges of the Tararua line lie beside those of the Eastern Sounds District (Fig. 2). For this purpose, it is uncertain whether the North Island should be considered as fitting closely into Cloudy Bay or simply moved along the shortest line to the eastern margin of the Sounds block. While the point does not affect the hypothesis as a whole, it renders uncertain the amount of movement involved. Roughly, this must lie between 15 and 25 miles.

The Marlborough schist is then continued northward in Kapiti Island, and possibly underlies Western Wellington beneath the younger Tertiary sediments. It may even continue, in part, beneath the volcanic centre of the North Island. This leads to the speculation that the fossiliferous greywackes west of the schist area may belong to the Kawhia line, e.g., *Pseudomonotis* beds, though not wholly coeval, in which case the bifurcation of the main line and the Kawhia line takes place in Southern Nelson.

The refitting described does not, however, solve the major problems of the correspondence of the Wairarapa and Awatere Tertiaries and the Kaikoura and Haurangi Mountains (with their peculiar structures involving the Amuri Limestone and the "Grey Marl"), for the South Island is still too far to the west. To bring the South Island back to the east, the Marlborough Sounds remaining with the North Island, requires some space into which to fit the Sounds block, which, for clarity, may be deemed as rotating about its apex at Tophouse.† This space is supplied by the triangular depression of Tasman Bay, only the head of which is filled with the Moutere gravels

* In the ensuing discussion the movements are reversed in time and direction for reconstructive purposes; the correct sequence of events is given in the short section on "Date of Formation" following.

† Incidentally, this is an area where change of drainage between the Buller, Wairau, and Motueka Rivers is apparent.

(Pliocene-Post-Pliocene). This movement was probably between 20 probably greywackes, must have been forced down and thrust below and 25 miles. When the movement took place, certain formations, the Marlborough schist[†] along the Wairau, and possibly other, fault-lines. At the same time torsional structures were developed in the north-east corner of Marlborough. I have noted elsewhere (1934, p. 9) how the north-eastward trending structures of the Kaikouras swing to the east in the Awatere-Ure River district. Possibly the eastward dipping limestones and marls of the Limestone Range block and the Benmore arc are extreme cases of this (Fig. 1). These movements, obscure when considered only with respect to their own vicinity, become intelligible when interpreted as due to thrust against the rigid Sounds block.

On such an hypothesis, the shores of Cook Strait should be determined by fractures, and Cotton has demonstrated that this is so. Moreover, the strong warping and tilting of ancient shorelines with respect to one another and to present sea-level is a clear indication that compression was an active agent in their elevation. The frequency of earthquake shocks and earth movements in the area must also be taken as an indication that final equilibrium has not yet been attained.

All movements—the remark is trite—are relative, and in a case such as this it may be argued that the result is the same whichever land mass underwent the major earth movement (South Island to the west or North Island to the east). This may be so between them; but with earth forces such as must have been in operation here, we should expect that the amount of deformation in the moving mass would be greater than in the stable one. If this is true, then undoubtedly the South Island moved, for the deformations of eastern Marlborough are much greater than those of the corresponding area in the North. Indeed, they display the only folding of considerable magnitude known from the Kaikoura orogeny and the greatest fault displacements recorded in New Zealand. We may say that the Island moved under the influence of thrust-forces operating at a maximum in Eastern Marlborough. Elsewhere, also, I have referred to under-thrust from the south-south-east as responsible for the rise of the Kaikoura and Haurangi Ranges and classed these as the youngest

[†] The closer relationship of the Marlborough Sounds rocks with those of North-West Nelson involved on this hypothesis, seems the more attractive the longer it is examined. A variety of schistose rocks together with Ordovician greywackes exists in North-West Nelson, both being intruded by ultrabasic masses. Some of these may be matched in the Sounds block though the closeness of the agreement has yet to be demonstrated in detail. Insistence should herein be placed on comparable phases of metamorphism rather than rock types, to allow for differences of age and facies in the materials before metamorphism took place.

The rocks of Nelson contain graptolites; these are not yet recorded from Marlborough, though in 1930 Mr W. J. Branch reported the finding of obscure markings on slate near Tuamarina. The writer must acknowledge with gratitude Mr Branch's great courtesy in sending the whole collection to South Africa for his personal re-examination, but has no hesitation in rejecting the material as graptolites, or indeed any recognizable organic form. The structures are produced by the oxidation of pyrites in the original shales.

mountain-forming movements of the Kaikoura Orogenic Cycle. It may be noted that the highest mountains developed are the Inland Kaikouras in the Tapuaenuku-Mt. Alarm area, at or very near the point where the island-separating forces were at a maximum.

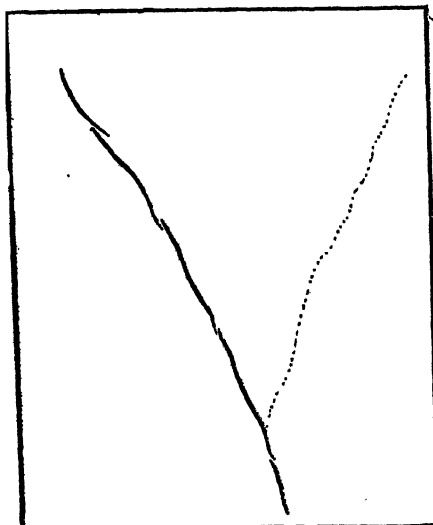
Furthermore, these mountains are all characterised by strong reversed faults with scarps facing to the east and their correlation with the Haurangi Mountains forms one of the most satisfactory features of the hypothesis. No longer is the Wellington-Tararua system of ranges with its westward-facing reversed faults to be correlated with wholly eastwardly directed Kaikoura system, as has been done since the time of Hochstetter.

The hypothesis requires also, if the Kaikoura Mountains are to be correlated with the Haurangis, that these elevations, together with the main ranges of the islands, should have been formed before Cook Strait. Moreover, the dislocation must have been sufficiently recent for the survival of topographical features which antedate it. In this connection we may instructively turn to published accounts of that classic area of deformation, the Swiss Alps.

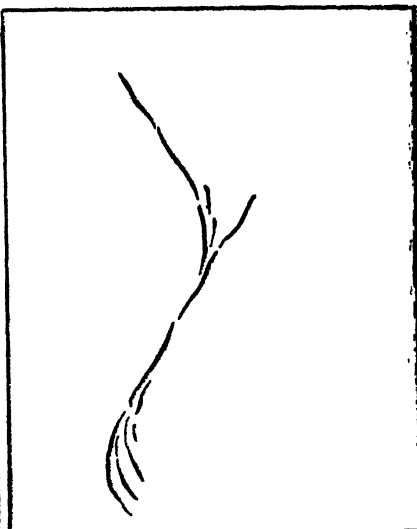
In the eastern Alps many cases are known of mountain ranges transected almost at right angles to their trend by faults of horizontal displacement. For these the term "Blatt" was introduced by Suess (1885, pp. 115-126). "Flaws" and "shift-planes" are terms which have been used later. The continuity of the mountain ranges is broken, in some cases the ridges being so displaced that they block opposite valleys to form lakes. Some of these are, even yet, in existence, e.g., Fahlensee, Seealpsee (Heim, 1921, p. 369). "Flaws" are also well known in the Jura Mountains. In the European examples, the maximum movement on any particular "flaw" does not exceed 800 metres, Cook Strait is on a much larger scale. It should be noted that these fractures are found only in the upper, folded formations, dying out in the material beneath the folds.

Suess has made the following pronouncement upon them: "In their normal form flaws are produced by a movement of two adjacent portions of the earth's crust in the same direction; but to an unequal extent. The parallelism of the movement of the two parts is often only present as regards direction, the dip of the beds being much steeper on one side than on the other." Thus, according to Suess, both sides move in the same direction; but one to a greater extent than the other. They are clearly the result of shearing due to stretching along the arc of the folding, and as Heim (1919, p. 615) has pointed out, they occupy not the ends but the central portion of the arc.

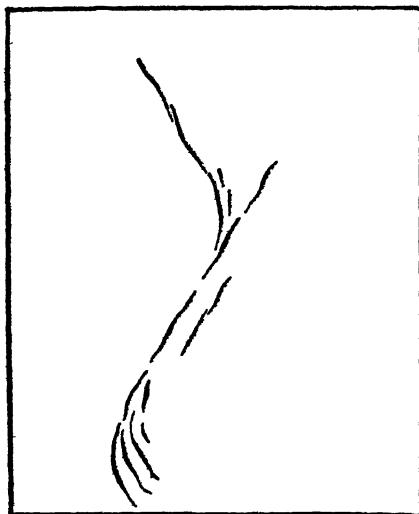
Bucher (1932, p. 247) has succinctly summed up the essentials of the Jura Mountain flaws: "The relation of the flaws to the anticlines shows that they came into existence in the course of folding, after the main lines of folding had been established, but before they were completed. The major axes of folding can be recognised on both sides of the flaws yet the final pattern of the folds shows a good deal of independent movement on opposite sides of each fracture." Substituting Cook Strait for the term "flaw" and (partly) block mountains for "anticlines and foldings" he has written a description of the central portion of New Zealand.



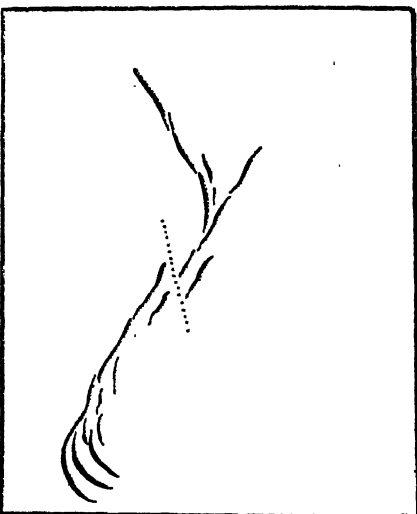
STAGE 1—The Older (New Caledonian) line is in existence and the Tonga-Kermadec Arc is developing.



STAGE 2—The Tonga-Kermadec ridge has risen into existence and, impinging against the old line, has buckled it from the centre of the N. Island to Otago.



STAGE 3—In the later stages of the buckling, the eastern ranges (Kaikouras and Haurangis) rise parallel to the Main Axis.



STAGE 4—As a final phase, dislocation occurs to just that amount which brings the eastern mountains of the S. Island opposite the western ranges of the N. Island.

FIG. 5—Skeleton Trends of the Mountain Ranges of the New Zealand Region.

The form of the Cook Strait "shift plane" shows a departure from the mathematical figure for dislocation under ideal conditions, in that it is noticeably "stepped" into two parts. This irregularity is readily explained as due to the influence exerted by the pre-existing strong "grain" of the folded Hokonui rocks.

It has been stated above that the Swiss features are on a far smaller scale than Cook Strait. Let us then take Cook Strait itself as part of a larger scheme. New Zealand occupies a position closely bound up with the presence of certain well-defined submarine ridges trending away to the north-west and north-east. These, the New Caledonia and Tonga-Kermadec arcs, enter the North Island along the North Auckland Peninsula and Raukumara Peninsula respectively, and meet in the centre of the Island (Fig. 5). The ranges then continue south-south-west to Wellington and the South Island, changing in trend only in Otago, where the South Alpine ranges run out to the south-east. In skeleton, the main trends are shewn in Fig. 5.

It is here suggested that the New Caledonia line is the older and that, with the formation of the Tonga arc, a bulge in the old line was produced in the position of the South Island, accompanied by the rise of mountains and, as a last phase, the formation of a flaw, conforming to the stress pattern of the system. The flaw is much larger than other described examples; but any difficulty in this respect is overcome by regarding it as merely in proportion with the great ocean ridges and deformations with which it is associated.

One may conclude this summary with a quotation which, though perhaps geologically old fashioned in context now, is none the less true:—

"If but a single line rendered a control possible, we should have already shown the great possibility of the correctness of our combination. But if we have n rows, then this probability is raised to the n th power."—A Wegener, *Origin of Continents and Oceans*.

THE DATE OF FORMATION.

The fact that there is a closer connection between the Awatere beds and the Tertiary rocks of the North Island than there is between them and the Tertiaries of North Canterbury and Southern Marlborough indicates that, at the time of their deposition, Cook Strait was not the boundary that it is now. Furthermore, the correspondence of the dual mountain ranges of the North and South Islands (neglecting the North-west Nelson Mountains), and their analogous structures, demonstrates clearly that they rose into being as continuous features, and that the present apparent dislocation was subsequent to the initiation of the present topography, i.e., Late Pliocene. With these movements it is intimately bound up, appearing as a final major phase. Elsewhere (1937), I have referred to the western mountains as being older than the eastern, so that the sequence of movements is probably as follows:—

1. Uplift of the western mountains,
2. Uplift of the eastern mountains,
3. First stage of dislocation. South Island moved to the west faster than the North. Tasman Bay "split" formed. (?) Torsion structures of North-east Marlborough begun.

4. Second stage of dislocation. South Island moved still farther to the west taking the Marlborough Sounds block with it. (Stages 3 and 4 are probably to be represented by both islands moving to the west; but the South Island faster relatively to the North.)

5. Infilling by Moutere gravels and the development of ancient strandlines to correspond with later, varied movements. The North Island has certainly partaken of these, a further indication that both islands have moved.

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Hornblende-gneisses, Marbles and Associated Rocks from Doubtful Sound, Fiordland, New Zealand.

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INTRODUCTION.

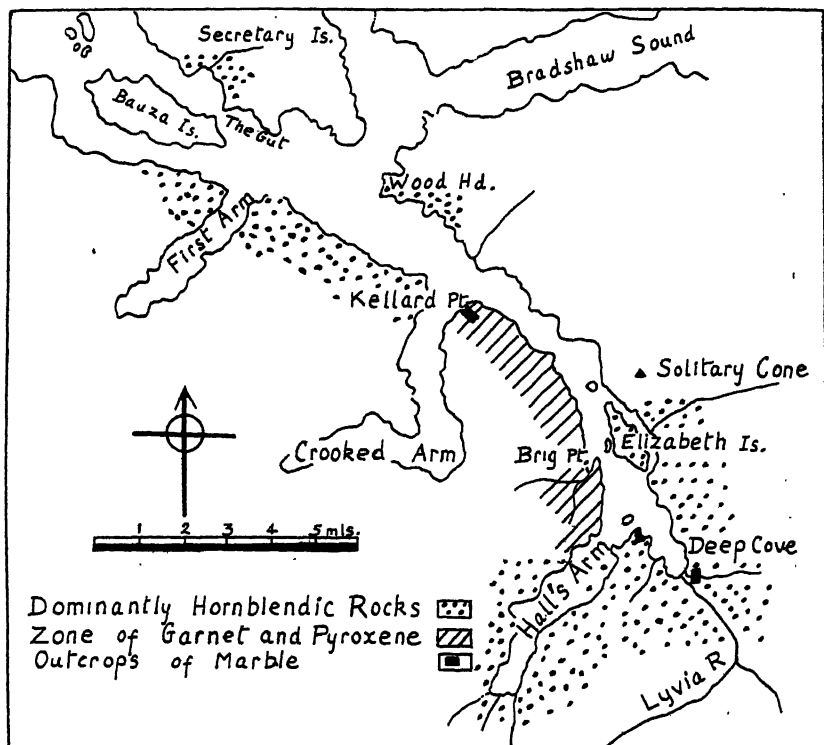
THE rocks which form the subject of this investigation were collected in December, 1937, during a visit to Doubtful Sound financed by a grant from the Australian and New Zealand Association for the Advancement of Science.

The Sound is one of the most extensive of the West Coast fiords and lies immediately west of Lake Manapouri, from the West and North Arms of which it is accessible via Wilmot and Fowler Passes respectively. Its maximum length, from the coast to the head of Hall's Arm, is about twenty-five miles, while the width varies from one to two miles. For the most part it is bordered by lofty precipices rising sheer from the water's edge and sloping steeply upward to the mountain summits, which in this district reach a height of between 4500 and 5000 feet. Dense forest fills the valleys and clothes all but the steepest slopes.

Geological work was practically confined to the shores, where continuous outcrops are beautifully exposed along the cliff bases. The portions examined in detail include the eastern shore from the north end of Elizabeth Island to the head of Deep Cove, the western shore from the head of Deep Cove to Kellard Point, and both shores of Hall's Arm. Rocks were also collected at intervals from the south-western shore between Crooked and First Arms, and from the southern side of Secretary Island. It is hoped to extend the work further on some future occasion.

The dominant rocks throughout the whole of this region are massive hornblendic, sometimes garnetiferous gneisses of "dioritic" aspect, locally merging into types rich in biotite, feldspar or pyroxene. At several points bands of marble and calc-gneiss are interstratified

with the hornblende rocks. Veins of granite-pegmatite occur here and there, but are never numerous. The whole association presents a marked contrast with that developed further east around Lake Manapouri, where granitic intrusions invade the hornblende-gneisses on a large scale (Turner, 1937a, 1937b, 1938).



Map of Doubtful Sound showing Distribution of Metamorphic Rocks in the Area Examined.

NOTE ON DETERMINATIVE METHODS.

In all 150 thin sections have been examined microscopically, following the normal procedure, without use of a universal stage. The composition of the plagioclase was determined in each case by a combination of methods described by Winchell (1933), use being made especially of extinction angles Z or X to (001) or (010) , in sections perpendicular to X and Z respectively (Winchell, 1933, p. 318). Selected sections were also examined with a universal stage, with the purpose of measuring axial angles for pyroxenes, epidote minerals and amphiboles, and checking the composition of the plagioclase. In all cases the compositions of plagioclase as determined by the two methods agreed reasonably closely; further, the axial angles of plagioclase as given by universal stage measurement were found to correspond closely with the curve given by Winchell (1933, p. 318). Typical data are given below in illustration [determinations (a) based on extinction angles, (b) based on measurements with universal stage]:—

Section No. 4608.

- (a) Section \perp X; Z to 010 = 88°
 Z to 001 = 4° } An_{18} or An_{22} .
- (b) Twin axis lies in composition plane; co-ordinates of pole of twin axis with respect to indicatrix axes, 9° (Z), 81° (Y), 86° (X).

Three possible solutions:—

Twin axis = $[100]$, An_{10} or An_{25} .

Twin axis = $\perp \frac{[100]}{(001)}$, An_{10} .

$2V = 88^\circ$ (+) and 86° (—); this favours composition An_{25} .

Section No 4595.

- (a) Section \perp X; Z to 010 = 65°
 Z to 001 = 33° } An_{48} .
- (b) Twin axis \perp (010), composition plane (010); co-ordinates of twin axis with respect to indicatrix axes, 27° (Z), 67° (Y), 87° (X); $2V = 76^\circ$ (+). } An_{45} .
- Twin axis $[010]$, composition plane (001); co-ordinates of twin axis 27° (Z), 63° (Y), 82° (X); } An_{44} .
 $2V = 74^\circ$ (+).

Section No. 4598.

- (a) Section \perp X; Z to 010 = 56°
 Z to 001 = 50° } An_{70} .
- Symmetrical extinction to (010) in twinned sections } An_{68} .
 \perp (010), 37° .
- (b) Twin axis $\perp \frac{[100]}{(010)}$, composition plane (010); co-ordinates of twin axis, 48° (Z), 54° (Y), 61° (X); } An_{70} .
 $2V = 90^\circ$.
- Twin axis \perp (001), composition plane (001); co-ordinates of twin axis 46° (Z), 63° (Y), 58° (X); } An_{78} .
 $2V = 84^\circ$ (—).
- Twin axis $\perp \frac{[100]}{(010)}$, composition plane (010); co-ordinates of twin axis 51° (Z), 63° (Y), 55° (X); } An_{79} .
 $2V = 84^\circ$ (—).

THE HORNBLLENDE-GNEISSES.

The most widely distributed rocks in Doubtful Sound are dark green coarse gneisses of "dioritic" appearance, which consist essentially of plagioclase and hornblende often accompanied by biotite and less commonly by epidote or quartz. Gneissic structure is usually distinct and may be very well defined (e.g., Nos. 4600 to 4603), but massive non-foliated rocks are occasionally met with (e.g., Nos. 4568, 4569, 4573). The structure results from a tendency for the dark minerals to be concentrated in streaks and bands, combined with parallel dimensional orientation of crystals of amphibole

and mica. Most rocks show marked cataclastic effects such as granulation and elongation of grains of quartz and plagioclase, with simultaneous bending of twin-lamellae and development of undulose extinction; these are most intense in rocks showing most strongly marked gneissic structure.

For convenience of description the hornblende-gneisses are divided into four groups, viz. :—

- (1) Hornblende-plagioclase-gneisses with minor biotite.
- (2) Hornblende-plagioclase-biotite-gneisses.
- (3) Hornblende-plagioclase-epidote-gneisses, usually containing biotite in fair abundance.
- (4) Non-feldspathic hornblende-biotite-gneisses.

Transition-types connect group (1) with the second and third groups.

(1) Hornblende-plagioclase-gneisses (Nos. 4557, 4558, 4566, 4568–4571, 4573–4576, 4580, 4594–4596, 4604, 4610, 4612, 4642–4645, 4648, 4649, 4654, 4658, 4681, 4682, 4688). These are dark-green rocks composed essentially of hornblende (30% to 60%) and plagioclase (30% to 60%) usually accompanied by biotite (10%) and small amounts of colourless rather poorly birefringent epidote.

The hornblende is a common green variety, usually with the pleochroism

X = pale yellow
Y = deep olive-green
Z = deep blue-green
Z > Y > X.

In some slides, however, the mineral is deep greenish-brown for vibrations parallel to Z (e.g., Nos. 4558, 4566, 4595). Schiller structure with grains of opaque iron-ore arranged along lines parallel to the *c* crystal axis is common; in one rock (No. 4688) the schiller inclusions are small prisms of yellow rutile, a feature typical of the non-feldspathic hornblende-gneisses. In the coarser rocks a stout prismatic habit is common and a tendency to develop sieve-structure may occasionally be shown (e.g., Nos. 4576, 4681), but in some of the finer-grained well-foliated rocks (e.g., No. 4594) the hornblende occurs as slender parallel prisms.

The plagioclase is typically basic oligoclase or acid andesine, ranging between Ab₇₅ and Ab₆₅ in composition, but a rather higher content of anorthite is usual in the feldspar of rocks from near the head of Deep Cove (No. 4557, Ab₅₈; No. 4669, Ab₄₈₋₅₀; No. 4576, ₅₆; No. 4595, AbAb₅₅₋₅₅₋₆₀). It tends to occur in equant grains often deformed and partly granulated as a result of shearing. Multiple twinning on several laws with (010) or (001) as composition plane is fairly common in undeformed grains.

Biotite is usually present in quantities less than 10%, but may be absent in some rocks. It is usually yellowish-brown, or in a few slides reddish-brown. In addition to the epidote already mentioned, common accessories are sphene, apatite and pyrite, while in one section (No. 4568) needles of yellow rutile are plentiful at

plagioclase-hornblende junctions. In several slides the percentage of sphene lies between 1% and 5% (Nos. 4573–4575, 4610, 4648, 4649, 4658). In Nos. 4573 and 4574 it takes the form of coarse rounded drop-like grains enclosed in hornblende or plagioclase, while in No. 4658 it is coarse and idioblastic, being conspicuous even in the hand-specimen. In other rocks (e.g., No. 4575) it occurs as large granular clusters 2 mm. to 3 mm. in diameter, enclosing highly corroded central cores of a deep golden-brown non-pleochroic, highly refractive mineral provisionally identified as rutile. Quartz was recorded in a number of rocks, usually in quantities between 5% and 10% (Nos. 4558, 4576, 4604, 4610, 4648, 4649, 4652, 4658, 4682). Calcite and scapolite occur as accessories in Nos. 4580 and 4682 respectively.

Frequently observed retrogressive mineralogical changes connected with late shearing include chloritisation of biotite, and conversion of hornblende to pale-green actinolite or tremolite (Nos. 4557, 4558, 4644). In rare instances (e.g., No. 4569) sharply crystallised flakes of pale chlorite free from any trace of relict biotite may have originated in some other way, possibly from the hornblende. The epidote, though present in only small quantities, usually appears to be a member of the original hornblende-plagioclase-biotite assemblage, but in special cases may be a product of later reaction during shearing. For example, a coarse hornblende-plagioclase-gneiss, No. 4569, has locally been reduced by shearing to a fine-grained variant in which about 5% to 10% of yellowish epidote and small amounts of secondary calcite accompany the dominant plagioclase and hornblende; the compositions of the plagioclases of the coarse and sheared phases are Ab_{48-50} and Ab_{85-50} respectively.

Structurally the hornblende-plagioclase-gneisses vary from coarse non-foliated rocks indistinguishable from diorites (e.g., Nos. 4573, 4574, 4569) to strongly foliated gneisses (e.g., Nos. 4557, 4558, 4576) similar to those described from Manapouri in previous papers (Turner, 1937a, 1937b, 1938).

(2) *Hornblende-plagioclase-biotite-gneisses.* (Nos. 4556, 4559, 4561–4563, 4565, 4577, 4599, 4646, 4652.) Rocks of this class (Fig. 1) contain between 15% and 30% of deep golden-brown biotite in addition to the usual plagioclase and hornblende (each ranging between 30% and 50% of the total composition). On account of the relatively high content of mica and its tendency toward parallel orientation, these rocks tend to have a more pronounced gneissic structure than is usually shown by the biotite-free members of the previously described group. The hornblende is the normal blue-green type, often showing schiller structure and in several sections replaced partially or almost completely by actinolite (e.g., No. 4565). The plagioclase ranges between Ab_{50} and Ab_{70} and shows the same characters as in the hornblende-plagioclase-gneisses. In most slides iron-ore is present as granules enclosed in hornblende, but other accessories are rare; in No. 4577, however, epidote, rutile and zircon are all present. Essential features of several typical slides are recorded below:—

No. 4556 is a “dioritic” gneiss with average grain of 1 mm., consisting of plagioclase (An_{42-48}) 40%, brown biotite 30%, amphibole

30% and accessory magnetite in granular clusters associated with the amphibole or mica. The original hornblende or pyroxene is now entirely replaced by pseudomorphous masses of prismatic actinolite, edged with a deep blue border against the enclosing feldspar. These resemble but are not structurally identical with pseudomorphous masses of actinolite in epidiorites from Manapouri (Turner, 1937a, p. 87).

No. 4562 is a similar coarse-grained rock of dioritic aspect in which compact brownish-green hornblende occurs in large equant grains with marked schiller structure. Several clinopinacoidal sections show a well-defined basal parting sub-parallel to \bar{X} and inclined at 72° to c ; this, taken in conjunction with the schiller structure, strongly suggests derivation from augite [cf. the Manapouri epidiorite, No. 2794 (Turner, 1937a, p. 87)].

Nos. 4559 and 4563 are fine-grained strongly foliated varieties reminiscent of the amphibolites from the islands of Lake Manapouri. The composition of No. 4559 is estimated as plagioclase (Ab_{70}) 50%–60%, hornblende 30%, biotite 10%–20%, and about 1% of iron-ore in rather coarsely granular streaks. The hornblende is in parallel, often twinned, elongated prisms usually with complex schiller structure. In addition to the usual strings of iron-ore oriented parallel to the vertical cleavages, many clinopinacoidal sections show oblique strings of included material making angles of 36° to 42° with c and reversed across the trace of the (100) twinning plane; this would agree with orientation parallel to (302). In other cases the central portions of hornblende crystals are crowded with masses of irregularly oriented grains of iron-ore.

No. 4646 differs from the other hornblende-plagioclase-biotite-gneisses in that it contains about 15% of intensely sheared quartz. The composition is hornblende 40%, red-brown biotite 25%, basic oligoclase 20%, quartz 15% and accessory sphene, epidote and apatite.

(3) *Hornblende-plagioclase-epidote-biotite-gneisses.* (Nos. 4600–4603, 4657, 4691, 4692, 4695.) The hornblende-gneisses containing epidote as an essential constituent differ in several respects from the rocks described in the two previous classes; coarse idioblastic prisms of epidote make up between 10% and 30% of the composition; the plagioclase is more sodic than in other hornblende-gneisses (Ab_{75} to Ab_{80}); streaky foliation is invariably very pronounced and not only involves parallel orientation of mica and hornblende, but in many cases may also be correlated with definite elongation of feldspar grains. Biotite is usually sufficiently plentiful (10% to 25%) to rank as an essential constituent of the mineral assemblage.

Nos. 4600–4603 are representative of the strongly foliated epidote-bearing gneisses from Elizabeth Island and the adjacent eastern shore of the Sound. In these rocks (Fig. 3) blue-green hornblende in coarse sometimes schillered prisms which may show well-developed sieve structure (Nos. 4602, 4603) makes up between 15% and 30% of the composition and is associated with less plentiful intensely pleochroic, yellowish-brown biotite. The plagioclase (40% to 60%) approximates in composition to Ab_{80} . Colourless, moderately birefringent coarse prisms of epidote (0.8 mm. \times 0.4 mm.) are abundant

in every section, while in some instances (Nos. 4600, 4601) the same mineral may also occur as smaller sharply idioblastic crystals enclosed in the larger grains of feldspar. Coarse sphene is always present, usually in the form of granular streaks associated with hornblende foliae; in No. 4603 it encloses small nuclei of iron-ore or of the yellow highly refractive mineral identified elsewhere as (?) rutile. Quartz occurs in small amounts in the biotite-hornblende streaks of No. 4603, while apatite is a constant accessory in all four sections.

Other rocks of this group are somewhat coarser in grain than the rocks from Elizabeth Island, especially as regards the epidote which takes the form of stout idioblastic prisms 2 mm. to 3mm. in length, sometimes exhibiting good sieve-structure (Nos. 4691, 4692) and in one slide (No. 4657) enclosing vermicular inclusions of intergrown quartz. Though always colourless, the epidote varies considerably as regards birefringence and axial angle, even within the limits of a single section. Thus in No. 4692 the following values of $2V$ were recorded for separate crystals, the sign in every case being negative: 64° , 74° , 75° , 84° , 86° ; this corresponds to variation from 55% to 86% of the clinozoisite molecule (i.e., from 22% to 7% Fe_2O_3)*. The presence of small amounts of quartz in Nos. 4657 and 4692, and of plentiful acicular rutile in No. 4691 is also noted.

In conclusion attention is drawn to the general similarity between some of the rocks just described and certain of the epidote-bearing hornblende-plagioclase-gneisses of the North Arm of Lake Manapouri, e.g., No. 2382 (Turner, 1937b, p. 228).

(4) *Non-feldspathic hornblende-biotite-gneisses*. (Nos. 4597, 4606, 4614-4617, 4617a, 4654). No. 4614 may be taken as typical of the least altered of the non-feldspathic hornblende-gneisses. The main constituent (80% of the rock) is hornblende in coarse crystals (2 mm. to 4 mm.) with strong pleochroism from pale yellow (X) to deep blue-green (Z); Z to $c = 22^\circ$. These are often riddled with small but well-formed prismatic crystals of pale yellow rutile showing parallel orientation. The remainder of the rock is composed of intensely pleochroic biotite ($X =$ very pale yellow, $Y = Z =$ deep greenish-brown), accompanied by accessory epidote, sphene and apatite.

No. 4617 is a somewhat sheared phase of the same rock, collected from the same locality. The coarse green hornblendes have been partially replaced by masses of twisted prisms of pale-green actinolite and are surrounded by a continuous matrix of actinolite and epidote; the latter is particularly plentiful along surfaces of shearing. Relatively coarse inclusions of rutile are enclosed abundantly in the hornblende relicts. Granular sphene is abundant as an accessory and often enclosed shapeless grains of deep yellowish-brown (?) rutile.

No. 4615, from the same locality, represents the end-product of shearing of a gneiss locally containing minor plagioclase. It is a completely schistose rock consisting of plagioclase (Ab_{75}) 10%,

* As determined from curves in Winchell (1933, p. 313).

epidote 50%, pale actinolite 20%, biotite 20%, and accessory apatite and coarse pyrite. Amphibole, fine-grained biotite and small epidote prisms make up a matrix enclosing the rounded feldspars which have apparently undergone rotation during the deformation. The hand-specimen shows a few relict aggregates of coarse hornblende scattered through a schistose matrix represented by the section.

No. 4654 is a variety in which dominant green hornblende with the usual enclosed prisms of rutile is accompanied by 10% of yellowish-brown biotite, 20% of plagioclase (Ab_{72}) and coarse sphene in accessory quantity. In No. 4656 pale bluish-green hornblende is the only constituent.

The frequent presence of rather coarse grains of yellow sulphide—probably pyrite—in most rocks of this group is noteworthy.

(5) *Origin of the Hornblende Gneisses.* One of the most difficult yet fundamental problems connected with the geology of Fiordland concerns the origin of the various hornblende-plagioclase-gneisses that occur so abundantly throughout this region. The rocks in question might conceivably belong to any of three categories:—

- (a) Primary gneissic diorites in which hornblende and plagioclase are essentially direct products of crystallisation from dioritic magma.
- (b) Basic and semibasic plutonic rocks that owe their present mineral composition and structure to deep-seated regional metamorphism (cf. Harker, 1932, pp. 282–286).
- (c) A series of basic lavas, tuffs and interstratified calcareous sediments or greywackes that have undergone intense regional metamorphism at depth (cf. Harker, 1932, pp. 268–270; Vogt, 1927, pp. 485, 486).

It seems likely that the hornblende-gneisses of Fiordland are not all of one origin; for example, in the vicinity of Preservation Inlet rocks that are definitely gneissic diorites and granodiorites occur as marginal phases of the main granitic intrusions (Benson and Bartrum, 1935), while the hornblendic gneisses of Lake Manapouri are certainly metamorphic even though the probability of igneous origin be admitted in many cases.

At Doubtful Sound the gneisses consisting of the associations hornblende-plagioclase, hornblende-plagioclase-biotite and hornblende-plagioclase-epidote-biotite, though separated for descriptive purposes, show gradual transition between all three types and are therefore regarded as of common origin. While the hornblende-andesine association might have resulted from either magmatic crystallisation or metamorphic recrystallisation, assemblages such as hornblende-oligoclase-epidote-biotite-sphene and the garnet-bearing associations to be described later must be regarded as metamorphic. The writer therefore believes that the hornblendic gneisses of Doubtful Sound, like those of Manapouri further east, have acquired their present mineralogical and structural condition during deep-seated regional metamorphism of pre-existing solid rocks.

In Table I analyses (A to E) are given of five hornblende gneisses from Lake Manapouri and Doubtful Sound, together with comparable analyses selected from Washington's tables (G and H) and the composition of Daly's average basalt (F). The rocks chosen for analysis are typical of the more basic hornblende-rich biotite-poor gneisses of both districts, and are representative of the group of rocks to which the term "diorite-gneiss" has been applied in earlier accounts of Fiordland geology.

	A	B	C	D	E	F	G	H
SiO ₂	52.16	49.13	49.40	47.83	54.27	49.06	52.27	49.29
Al ₂ O ₃	17.37	17.04	18.25	17.80	18.40	15.70	17.68	18.49
Fe ₂ O ₃	1.73	3.88	2.85	2.58	1.02	5.38	2.51	2.38
FeO	5.25	7.32	6.55	7.99	7.32	6.37	5.00	6.77
MgO	5.07	4.90	4.87	6.87	3.35	6.17	6.05	6.09
CaO	7.80	7.79	8.69	9.51	7.27	8.95	8.39	8.14
Na ₂ O	4.56	3.90	3.94	3.10	4.14	3.11	4.19	3.93
K ₂ O	1.90	1.57	1.58	0.54	1.09	1.52	1.58	1.79
H ₂ O								
above 105° C.	1.72	1.36	1.82	1.93	0.62	1.62	0.82	0.88
below 105° C.	0.18	0.14	0.08	0.21	0.02			
CO ₂	—	—	—	0.14	0.44		tr.	
TiO ₂	1.29	1.84	1.36	1.22	1.00	1.36	1.49	2.22
P ₂ O ₅	0.45	0.74	0.42	0.29	0.40	0.45		tr.
ZrO ₂	—	—	—	—	tr.			
S	0.33	0.06	0.02	0.04	0.53			
MnO	0.11	0.26	0.13	0.17	0.15	0.31	0.23	0.22
NiO	tr.	tr. (?)	tr.	—	—			
Cr ₂ O ₃	tr. (?)	tr. (?)	0.01	0.02	—			
BaO	0.07	0.07	0.08	0.02	0.04		0.06	
SrO	0.11	0.04	0.02	0.04	0.12			
Total ..	100.10	99.99	100.07	100.30	100.18		100.27	100.20

TABLE I.—ANALYSES OF HORNBLende-GNEISSES.

A—No. 2373, plagioclase-hornblende-epidote-biotite-gneiss, West Arm, Lake Manapouri. Anal., F. T. Seelye.

B—No. 2429, fine-grained amphibolite, Mahara Island, Lake Manapouri. Anal., F. T. Seelye.

C—No. 4514, fine-grained amphibolite, South Arm, Lake Manapouri. Anal., F. T. Seelye.

D—No. 4569, coarse hornblende-plagioclase-gneiss, Deep Cove, Doubtful Sound. Anal., F. T. Seelye.

E—No. 4594, hornblende-plagioclase-gneiss, Deep Cove, Doubtful Sound. Anal., F. T. Seelye.

F—Average basalt (Daly, 1933, p. 17, no. 58).

G—Quartz-basalt, New Mexico (Washington, 1917, p. 486, no. 60).

H—Basalt, Japan (Washington, 1917, p. 512, no. 248).

The fine-grained amphibolites (B and C) from Manapouri (Turner, 1937a, p. 85; 1938, p. 126) and the typical coarse "dioritic" gneiss (D) from Doubtful Sound agree sufficiently closely to indicate origin from similar parent rocks. Their compositions are consistently basic and show close agreement with various basaltic and gabbroid rocks (e.g., H) listed in Washington's tables, and may be compared with Daly's average basalt (F). The coarse hornblende-gneiss No. 2373 (A), typical of the gneisses of West Arm, Lake Manapouri (Turner, 1937b, p. 228), is also probably of basaltic or gabbroid

origin (cf. quartz-basalt, G), while a fine-grained rock (E) from Doubtful Sound shows fair correspondence with a number of diorites and gabbros listed by Washington. The derivation of the hornblendic phases of the Manapouri and Doubtful Sound gneisses from basic igneous rocks is thus established with reasonable certainty. It should be noted, however, that rocks with plentiful biotite have not yet been analysed, and may well include tuffaceous and sedimentary as well as probably igneous rocks.

There still remains the vexed question as to whether the gneisses in their premetamorphic condition were in the main plutonic rocks (dominantly gabbro or diorite) or a mixed series of lavas, tuffs and sediments as suggested in earlier papers for the rocks of Manapouri. While the latter alternative seems more probable to the writer, it seems preferable at this stage not to present a final conclusion on a problem not yet fully investigated, but to summarise the available evidence bearing upon the question.

In favour of a plutonic origin the following points are put forward:—

(a) The typically dioritic structure and mineral composition of some of the less gneissic rocks, particularly specimens from the eastern shore of Deep Cove within a mile of the head of that Arm. This is offset, however, by the basic rather than semibasic composition of typical "diorite" gneisses such as No. 4569.

(b) The occasional presence of hornblende that appears to be pseudomorphous after diallagic pyroxene, e.g., No. 4562 described above; the widespread development of schiller structures even suggest that replacement of augite may have been much more frequent than is otherwise indicated.

(c) The anorthite-content of the plagioclase in the least gneissic "dioritic" rocks is noticeably higher than in the strongly foliated rocks, and epidote is often abundant in the latter. While not conclusive, this suggests conversion of anorthite to epidote during metamorphic transition from diorite to gneiss.

(d) The composition of the non-feldspathic hornblende-biotite gneisses is strongly suggestive of origin by reconstitution of pyroxenites. Although it is impossible to be certain, the field relations of these rocks to the adjacent plagioclase-bearing gneisses (as shown about $1\frac{1}{2}$ to 2 miles from the head of Deep Cove on the western shore) support an intrusive origin.

The contrasted view that the hornblende- and associated gneisses represent a mixed series of lavas, tuffs and sediments has already been put forward by the writer for the corresponding rocks of Lake Manapouri (Turner, 1937a, p. 86; 1937b, p. 237). At Doubtful Sound the banded structure noted at Manapouri is not so prominent nor so regular, but at many points bands of quartzo-feldspathic gneiss that appears more probably sedimentary than igneous are interstratified with gneisses of "dioritic" aspect and composition. More significant is the occurrence, at three widely separated localities, of lenses and beds of marble in intimate association with hornblendic gneisses. These could be interpreted only as members of a stratified

series, or as major roof-fragments engulfed in a plutonic intrusion. The low dip and great extent of the main exposed mass of marble (that of Kellard Point) are somewhat against the latter alternative.

Typical hornblende gneisses occurring as small discontinuous parallel lenses and bands surrounded by marble include the following specimens:—

No. 4594. Fine-grained well-foliated hornblende-plagioclase-biotite-gneiss consisting of plagioclase (Ab_{70}) 50%–60%, blue-green hornblende 30%, red-brown biotite 10%, epidote 2%, pyrite* 2% and accessory sphene and apatite. Comparable with the amphibolites of Holmwood and adjacent islands, Manapouri, and with Nos. 4559 and 4563, Doubtful Sound. For analysis, see Table I.

No. 4595. Coarse hornblende-plagioclase-gneiss consisting of brownish-green hornblende 40%–50%, plagioclase (Ab_{52-57}) 40%–50%, colourless epidote 5%, red-brown biotite 5% and accessory apatite, sphene and iron-ore. Section No. 4591 from the same locality shows hornblende-plagioclase gneiss of this type apparently interbedded with diopside-gneiss (an impure phase of the marble).

No. 4596. Hornblende-plagioclase-biotite-gneiss with accessory epidote, pyrite, sphene and apatite.

No. 4642–4644. Coarse hornblende-plagioclase-gneiss in which the two principal minerals make up 95% of the composition. Minor biotite, epidote, sphene and often pyrite. Secondary actinolite developing from hornblende in No. 4644. Composition of plagioclase Ab_{70-75} .

No. 4655. A similar rock to the above, but containing 10% red-brown biotite.

No. 4646. Hornblende-plagioclase-biotite-quartz-gneiss (see earlier description).

No. 4649. Coarse hornblende-plagioclase gneiss with 5% colourless epidote and 5% sphene with lamellar structure.

No. 4669. Hornblende-plagioclase-epidote-gneiss containing small amounts of calcite, biotite, pyrite and apatite. Granulation is strongly marked and the hornblende shows a tendency to be replaced by pale actinolitic amphibole.

THE FELDSPATHIC GNEISSES.

(1) *Oligoclase-quartz-gneisses*. (Nos. 4572, 4579, 4605, 4607–4609, 4613, 4641, 4650, 4653, 4659, 4660, 4661, 4663, 4665, 4666,* 4680, 4683). Quartz-bearing oligoclase-gneisses occur in association with the hornblende gneisses throughout the whole of the region examined by the writer. Oligoclase of basic to medium composition (Ab_{68-80}) makes up between 40% and 80% of the composition of these rocks and is usually accompanied by between 10% and 25% of quartz.

* Mr F. T. Seelye, who analysed this rock, has noted that much of the "pyrite" is probably pyrrhotite, since H_2S is evolved rapidly when the rock is treated with dilute HCl .

Rarely the quartz content is as low as 5% (Nos. 4605, 4607) and in one section was estimated as 30% (No. 4641). Typically biotite is an essential constituent ((10%–20%) and may even reach 25% to 30% in some sections (Nos. 4665, 4666*). A few sections, however, are poor in dark minerals, and approach the trondhjemite-gneisses of Manapouri in appearance and composition (e.g., Nos. 4608, 4641). Epidote is constantly present in small amount, and in a number of rocks is almost or quite as plentiful as biotite (e.g., Nos. 4609, 4650, 4665, 4666*). It is the usual colourless moderately birefringent type, and in the single instance where the axial angle was measured (No. 4608) gave $2V = 76^\circ$ (negative), corresponding to a clinozoisite content of about 75%. Blue-green hornblende accompanies the biotite as a minor constituent (10%) in several sections (e.g., Nos. 4579, 4609, 4613, 4659), and in others is present in accessory amounts.

Sphene and apatite are ubiquitous accessories, and in some rocks the former may make up two or three per cent. of the total composition (e.g., No. 4659). Small crystals of zircon were noted in three sections (Nos. 4572, 4579, 4607). Less frequent accessory minerals are rutile (Nos. 4607, 4608), muscovite (apparently primary in Nos. 4607 and 4608) and allanite (Nos. 4572, 4607, 4608). The latter mineral is strongly pleochroic with

X = pale yellow

Y = deep plum-colour

Z = greenish yellow

X < Y > Z.

Small amounts of potash-feldspar occur interstitially in the trondhjemite-like section No. 4608, but the hand-specimen shows more biotite than is typical in the Manapouri trondhjemites.

As seen microscopically most of the oligoclase-gneisses have a more or less granitoid structure, with coarse feldspars, parallel flakes of mica, and interstitial, granular, often sheared quartz. Cataclastic structure is very pronounced in some sections (e.g., Nos. 4660, 4661, 4663, 4683). Quartz is finely granulated and drawn out into elongated streaks between the larger feldspars, which themselves are considerably crushed in such rocks, while biotite and epidote are reduced to strings of small grains and flakes. The extreme end-products are rocks of almost myloritic texture (e.g., No. 4683).

As in the more feldspathic gneisses of Manapouri, the rocks just described are characterised by association of oligoclase, quartz and biotite with variable amounts of epidote, hornblende and sphene. The Doubtful Sound rocks are consistently poorer in dark minerals, however, and especially in hornblende. Nevertheless individual specimens from the Spey River, Wilmot Pass and the western side of South Arm, Manapouri, agree fairly closely with the oligoclase-quartz-gneisses of Doubtful Sound.

	I	J	K
SiO ₂	58.88	59.59	58.34
Al ₂ O ₃	17.97	17.31	18.08
Fe ₂ O ₃	2.16	3.33	3.23
FeO	3.30	3.13	3.87
MgO	2.69	2.75	2.07
CaO	5.16	5.80	5.76
Na ₂ O	5.04	3.58	5.65
K ₂ O	2.30	2.04	1.30
H ₂ O			
above 105° C.	1.04	} 1.26	0.55
H ₂ O			
below 105° C.	0.02		0.05
CO ₂	—		0.12
TiO ₂	0.88	0.77	1.07
P ₂ O ₅	0.39	0.26	0.22
ZrO ₂	—		
S	0.09		
MnO	0.09	0.18	
NiO	—		
Cr ₂ O ₃	—		
BaO	0.07		
SrO	0.08		0.07
Total ..	99.96	100.00	

TABLE II.

I—No. 4666, oligoclase-quartz-biotite-epidote-gneiss, Kellard Point, Doubtful Sound. Anal. F. T. Seelye.

J—Average andesite (Daly, 1933, p. 16, no. 49).

K—Diorite, Hesse (Washington, 1917, p. 500, no. 157).

Their origin is doubtful. Neither sedimentary nor igneous rocks of corresponding composition are common. To the writer it seems perhaps most probable that feldspathic sands or tuffs were the parent rocks. No. 4666, which, however, is hardly typical of the group as a whole, is fairly close to certain andesites and diorites in composition. (See Table II.)

(2) *Plagioclase-gneisses without Quartz*. (Nos. 4598, 4651, 4655.) No. 4598 is a coarse white feldspathic rock with local patches of amphibole. In section the main constituent is bytownite (Ab₁₇₋₃₀) occurring in coarse equant twinned grains making up 80% of the rock. The amphibole (10%) is a colourless to pale-green member of the actinolite-tremolite series, in sheaves of prismatic crystals often showing multiple twinning; 2V was determined as 86° (negative). The remainder of the rock consists of colourless optically positive chlorite here and there enclosing biotite relicts, a little secondary sericite, and accessory coarse colourless epidote (2V = 83°, negative) and apatite. This rock, which is unlike any other recorded from Doubtful Sound, was collected from a small boulder at the waterfall near the head of Deep Cove. It is possibly gabbroid, but on the other hand is more probably a phase of the calc-gneisses that occur in association with marble at this locality. In any case development of actinolite and chlorite appear to be effects of a late (low-temperature) phase of metamorphism.

No. 4651 is a local quartz-free phase of the associated oligoclase-quartz-gneiss No. 4650. Its composition is oligoclase 90%, biotite 8%, epidote 2%, and accessory allanite, apatite, sphene and iron-ore.

No. 4655 consists of plagioclase 70%, epidote 15%, biotite 10%, hornblende 5%, and accessory epidote, sphene and apatite.

(3) *Plagioclase-quartz-microcline-gneisses.* (Nos. 4611, 4617b.) Potash-feldspar occurs in noteworthy amount in only two of the feldspathic gneisses. Though the composition of the section in each case approaches that of certain of the trondhjemites and oligoclase-granites of Manapouri, it is obvious from the hand-specimens that the rocks in question are merely microcline-bearing variants of the oligoclase-gneisses with which they are intimately associated.

The composition of No. 4611 is estimated as oligoclase-andesine 50%, quartz 20%, coarse perthitic microcline 10%, biotite 10%, epidote 5%, muscovite 3%, apatite 1%, garnet 1% and a few prisms of zircon. The macrostructure is highly gneissic. Beneath the microscope granulation of quartz and mica between the larger feldspar grains is perfectly shown. No. 4617(b) is a similar rock containing sphene, allanite, apatite and zircon as accessories.

It is not improbable that the microcline occurring in rocks of this type has been introduced from magmatic sources, as is probably the case with microcline-bearing phases of the plagioclase-hornblende-biotite-gneisses of Manapouri. The presence of allanite in some of the oligoclase-quartz-gneisses is also probably due to the influence of magmatic emanations derived from subjacent intrusive granite (cf. Turner, 1937b, p. 239).

THE GARNET-BEARING GNEISSES.

Along the northern shore of Hall's Arm and the western shores of the Sound between Hall's and Crooked Arms the grade of metamorphism rises, and garnet is conspicuous in many of the gneisses exposed in this neighbourhood. Typical specimens are Nos. 4679, 4684, 4685, 4686, streaky non-fissile rocks in which large shattered porphyroblasts of red garnet are enclosed in a dark matrix containing abundant hornblende, biotite or diopside. In many places the garnet porphyroblasts occurring in any individual specimen (e.g., No. 4685) are crossed by closely spaced parallel fractures (*ac* joints of Sander) constantly oriented perpendicularly to the linear foliation. Two contrasted types of garnet-gneiss rich in biotite and diopside respectively are described below:—

In section No. 4679 coarse augen of plagioclase 3 mm. or more in diameter are enwrapped by subparallel prisms of epidote and flakes of brown biotite; cataclastic structures are not developed, however. The composition was estimated as plagioclase (Ab_{70}) 30%–40%, quartz 15%–20%, biotite 25%, epidote 10%, hornblende 5%, garnet 3% and accessory apatite. Sieve structure is well exhibited by the large garnets and coarse prisms of colourless epidote, while the latter may sometimes enclose intergrown vermicular quartz. In the hand-specimen garnet is considerably more plentiful than in the section.

The rock is closely similar to coarse garnet-gneisses from Milford Sound (cf. G. 4 and G. 18 of Marshall, 1907, p. 500; An 1, An 9, An 11 of Speight, 1910, p. 265).

No. 4686 has an entirely different composition, viz., plagioclase 40%, pale green diopside 30%, garnet, 20%, hornblende 5%, biotite 5%, rutile 1% and accessory iron-ore and apatite. The plagioclase is basic oligoclase (Ab_{73}) in coarse equant grains 1 mm. to 2mm. in diameter often showing incipient peripheral granulation. The hornblende shows a rather unusual pleochroism.

X = pale yellow

Y = deep brownish yellow

Z = deep green with a yellowish tinge.

Z = Y > X.

The mineral identified as rutile is the same as that referred to in the description of the hornblende-plagioclase gneisses. No. 4684 is closely similar to the above, but the section contains less garnet and correspondingly greater amount of plagioclase (Ab_{75-80}).

Leucocratic garnet-feldspar granulites or gneisses of quite a different type (Nos. 4693, 4694) were collected from narrow sharply-defined bands cutting hornblende-plagioclase-epidote-gneiss (No. 4692) on the northern shore of Hall's Arm.

No. 4693 represents a vein four inches in thickness cutting almost perpendicularly across the foliation of the enclosing hornblende gneiss. It is a white feldspathic rock studded with red grains of garnet (2 mm. to 5 mm.) that make up about 25% of the bulk composition. In the corresponding section garnet is a good deal more plentiful. The feldspar is entirely plagioclase (Ab_{68-74}) and is considerably sheared and granulated. A strongly pleochroic highly birefringent mineral optically indistinguishable from biotite (X = pale yellow, Z = deep green), is frequently associated with the garnet, both marginally and along cracks in the larger fractured grains; this is possibly a ferruginous "chlorite" allied to stilpnomelane or bowlingite. Colourless epidote is present in small amounts together with accessory apatite, hornblende and iron-ore. No. 4694* (stream boulder) is macroscopically similar to No. 4693 but differs entirely in structure and in the presence of diopside and orthoclase. About 50% of the section is made up of plagioclase (about oligoclase-andesine) and minor orthoclase, both in a partially granulated condition. Enclosed in the feldspathic matrix are ill-defined composite spots consisting of garnet, diopside and quartz (Fig. 5). The central portion of each spot consists of aggregated equant grains of pale-green diopside sometimes with one or two grains of pink hypersthene at the centre itself. The nucleus of pyroxene is surrounded by a border consisting of pink garnet and interstitial quartz, with quartz occurring also as small inclusions in some of the garnet grains. Coarse yellow rutile is often present in the outer zones, less commonly in the pyroxenic nuclei of these aggregates. The section also shows a string of larger slightly darker crystals

* For analysis, see Table III.

of garnet without sieve structure, and apparently unrelated to the composite pyroxene-garnet spots. A few prisms of apatite and flakes of biotite were also noted. The rock appears to be closely comparable both structurally and mineralogically with a gneiss from Duck Cove, Doubtful Sound, described by Marshall (1907, p. 501; G. 24) and Speight (1910, p. 260; D. 3).

An isolated occurrence of melanocratic garnet-gneisses in association with sheared hornblendic gneisses about half-a-mile from the head of Deep Cove on the south-western shore is represented by Nos. 4554, 4555,† 4560. The chief constituents of the sections are biotite 40%–50%, amphibole 25%–40%, oligoclase-andesine 15% and garnet 5%–10%. The coarse flakes of biotite appear quite unaltered and show an unusual pleochroism from very pale yellow (X) to deep brownish-yellow (Y and Z). The amphibole is pale bluish-green actinolite, in aggregates of slender prisms often more strongly coloured at the margins than centrally, just as has been recorded for the secondary amphibole in associated hornblende-gneisses. Coarse

	L	M
SiO ₂	43.04	55.81
Al ₂ O ₃	18.03	18.61
Fe ₂ O ₃	1.20	0.42
FeO	11.55	7.06
MgO	11.12	4.02
CaO	3.38	7.20
Na ₂ O	1.52	3.13
K ₂ O	4.89	1.79
H ₂ O		
above 105° C.	3.54	0.18
H ₂ O		
below 105° C.	0.39	0.09
CO ₂	—	—
TiO ₂	0.88	1.07
P ₂ O ₅	0.24	0.44
ZrO ₂	—	tr.
S	0.14	0.02
MnO	0.18	0.12
NiO	0.02	—
Cr ₂ O ₃	tr. (?)	0.01
BaO	0.05	0.08
SrO	0.01	0.10
Total ..	100.18	100.15*

TABLE III.

L—No. 4555, garnet-biotite-gneiss, Deep Cove, Doubtful Sound. Anal., F. T. Seelye.

M—No. 4694, garnet-plagioclase-diopside-gneiss, Hall's Arm, Doubtful Sound. Anal., F. T. Seelye.

* To this should be added Rare Earth Oxides, 0.06.

fractured grains of garnet in Nos. 4554 and 4560 have suffered partial replacement by sharply crystallised, colourless to green chlorite (sign positive, twinning frequent) (see Fig. 4). In the third section the garnets are shattered, but the fractures are filled with fine-grained plagioclase and biotite, chlorite being absent. The analysis

† For analysis, see Table III.

of No. 4555 is quite different from that of any igneous rock recorded in Washington's tables. The rock appears to be a derivative of an aluminous sediment rich in FeO and MgO.

THE HYPERSTHENE GNEISSES.

Two rocks containing abundant hypersthene as well as diopside (Nos. 4687, 4689*) were collected from the stretch of coast between Hall's and Crooked Arms, where they occur associated with the garnet-gneisses described in the previous section. The estimated composition is plagioclase 50%–60%, hypersthene 25%, diopside 10%–20%, minor deep yellowish-green hornblende, and accessory quartz, apatite and iron-ore (Fig. 6). The plagioclase (Ab_{65-70}) is considerably granulated and shows only occasional twinning. The hypersthene is intensely pleochroic (X = bright salmon-pink, Z = sea-green) and shows notable dispersion of the optic axes ($r < v$). It is optically negative, with $2V = 62^\circ$ – 70° , corresponding to a composition between 32% and 42% $FeSiO_3$ —a surprisingly low iron-content in view of the intensity of the absorption tests. The analysis (Table IV) corresponds fairly closely with that of the oligoclase-biotite-epidote-quartz-gneiss, No. 4666.

	N	O
SiO ₂	55.52	55.93
Al ₂ O ₃	18.31	18.32
Fe ₂ O ₃	2.14	2.39
FeO	4.74	4.91
MgO	3.51	3.97
CaO	6.52	6.17
Na ₂ O	4.79	4.29
K ₂ O	1.93	2.62
H ₂ O		
above 105° C.	0.49	} 0.22
below 105° C.	0.12	
CO ₂	—	
TiO ₂	1.14	0.81
P ₂ O ₅	0.49	0.56
ZrO ₂	—	
S	0.11	
MnO	0.11	0.14
NiO	—	
Cr ₂ O ₃	—	
BaO	0.07	
SrO	0.09	
Total	100.08	100.33

TABLE IV.

N—No. 4689, hypersthene-diopside-plagioclase-gneiss, Doubtful Sound. Anal., F. T. Seelye.

O—Orthoclase gabbro-diorite, Yellowstone National Park, U.S.A. (Washington, 1917, p. 484, no. 38).

Perhaps originally of similar composition is No. 4690, in which the only recognisable pyroxene is diopside in a state of partial replacement by actinolite; it is possible that some of the actinolite

* For analysis, see Table IV.

aggregates represent hypersthene, though no trace of that mineral is still preserved. As in the hypersthene-bearing gneisses garnet is absent, but biotite is a minor constituent.

A hypersthene-gneiss without diopside (No. 4564) is associated with melanocratic garnet-gneisses and hornblendic gneisses on the western side of Deep Cove, half a mile from the head. In this rock plagioclase (Ab_{46-50}) is associated with abundant hypersthene and yellow-brown biotite, minor pale hornblende, a little secondary actinolite and accessory apatite. The hypersthene is almost colourless, but the axial angle has a much lower value ($2V = 46^\circ-50^\circ$, negative) than was determined for the strongly pleochroic hypersthene of the other gneisses, indicating a composition correspondingly richer in $FeSiO_3$ (60%–65%). Most crystals are bordered by a narrow rim of secondary pale-green to colourless actinolite ($2V = 76^\circ$, negative).

THE MARBLES AND CALC-GNEISSES.

Marbles and associated rocks composed of calc-silicates were observed at three localities, viz., at Kellard Point a short distance in from the entrance of Crooked Arm, at the southern headland of the entrance to Hall's Arm, and at the great waterfall on the eastern side of the head of Deep Cove. Calc-silicate gneisses not associated with marble were also recorded just south of the entrance to First Arm and on the eastern shore of the Sound half a mile from the head of Deep Cove.

The marbles (Nos. 4582, 4593, 4618, 4634, 3667, 3670, 4673, 3677) consist of a mosaic of coarse usually twinned grains of calcite* enclosing isolated rounded crystals or composite spots of silicate minerals (Fig. 8). At Kellard Point the dominant marble is copiously flecked with golden-brown phlogopite (almost colourless and uniaxial in section), which typically is accompanied by pale diopside (No. 4673) or occasionally by brilliant flakes of graphite (No. 4677). Less common at this locality are marbles containing isolated grains of scapolite, orthoclase, diopside and phlogopite (No. 4670), or scapolite, diopside and clinozoisite (No. 4667). The two sectioned specimens from near Hall's Arm are simpler types containing in one case diopside (No. 4618) and in the other phlogopite (No. 4634). More complex associations of silicates characterise the marbles from the Deep Cove waterfall (Nos. 4582, 4593). In the latter rounded isolated grains of quartz, diopside, epidote, scapolite and sphene and a composite cluster of diopside, epidote, microcline and apatite were recorded. In No. 4582 there are several patches (2 mm. to 5 mm. wide) consisting of microcline, quartz, labradorite, pale amphibole, diopside, biotite and zoisite (the latter intergrown with quartz), while the remainder of the rock is spotted with single grains of orthoclase, perthite, microcline, diopside and a colourless epidote mineral with very low birefringence and anomalous blue interference tints (zoisite or clinozoisite). Thus in the Doubtful Sound marbles the minerals commonly occurring singly in equilibrium with calcite are diopside, phlogopite, scapolite, potash feldspar, zoisite, clinozoisite, quartz, sphene.

* Staining tests with ferric chloride and ammonium sulphide show that dolomite is almost absent.

The calc-silicate rocks occur mainly as small nodules and discontinuous streaks up to four inches in thickness enclosed in or adjacent to marble. In addition to the hornblende and biotite-rich bands already referred to, the essential associations recorded are as follows:—

Epidote-diopside-sphene-quartz: with dominant epidote, Nos. 4619, 4622, 4627, 4628; with dominant diopside, Nos. 4626, 4639.

Epidote-diopside-quartz (with minor microcline, sphene and calcite): Nos. 4588, 4589.

Epidote-diopside-plagioclase: Nos. 4591, 4592, 4668 (with minor hornblende, scapolite and sphene).

Epidote-quartz: Nos. 4629, 4636, 4578 (with minor hornblende and apatite).

Zoisite-diopside-plagioclase (with minor biotite or hornblende, and sphene): Nos. 4674, 4678, 4672 (with epidote in addition).

Zoisite-scapolite-quartz (with epidote): Nos. 4583, 4647.

Diopside-hornblende-plagioclase-epidote: Nos. 4591, 4592.

Diopside-epidote-zoisite-scapolite-quartz: Nos. 4587 (with microcline), 4590 (with bytownite).

Plagioclase-quartz-epidote-sphene: Nos. 4633, 4635.

Plagioclase-actinolite-epidote-sphene: Nos. 4630 (with minor diopside and orthoclase), 4640 (with plentiful quartz), 4671.

Garnet-diopside-epidote-quartz: Nos. 4620, 4621, 4625.

Garnet-diopside-quartz-calcite: No. 4676.

Diopside-epidote-scapolite-garnet (with minor plagioclase and sphene): No. 4631.

Microcline-hornblende-epidote-zoisite-diopside-plagioclase-quartz-biotite-scapolite (with accessory sphene and apatite): No. 4586.

Microcline-scapolite-anorthite-zoisite-quartz: No. 4583.

Plagioclase-diopside-hornblende-epidote-calcite-microcline-quartz: Nos. 4662, 4664.

Minerals of the epidote group occur in almost every section, and include three varieties, viz., epidote, clinozoisite and zoisite, all of which may sometimes be associated in a coarsely crystalline condition within the limits of a single rock-section (e.g., Nos. 4583, 4587, 4590). The most widely distributed variety is a moderately to highly birefringent, colourless, optically negative epidote, that characteristically occurs as very coarse irregularly bounded crystals not infrequently enclosing numerous small granules of quartz, calcite or sometimes plagioclase (e.g., Nos. 4622, 4668, 4671). Usually less plentiful than epidote is colourless clinozoisite occurring either as separate prismatic crystals (e.g., No. 4590) or as narrow marginal zones bordering grains of epidote (e.g., No. 4583). Low birefringence and strong dispersion combine to give a characteristic anomalous blue interference tint which is intensified as extinction is approached and gives place to brownish yellow after extinction is passed. The positive sign and large axial angle are distinctive: $2V = 72^\circ$ (No. 4678); $2V = 66^\circ, 90^\circ$ (both in No. 4590). As shown by the variable

axial angle the almost iron-free clinozoisite grades through types containing a small amount of iron into the colourless optically negative epidote just described. In the rocks of Doubtful Sound zoisite always takes the form of elongated, sharply bounded, rather coarse colourless prisms, typically grouped in subparallel position and separated by coarsely intergrown quartz (Fig. 7). It is distinguished from the clinozoisite which so often is also present by its normal grey-white interference tints and consistently small optic axial angle: $2V = 10^\circ$, 30° – 40° , 40° (No. 4678); 35° – 40° (No. 4583a), 30° – 35° , 40° (No. 4590). The sign of elongation is positive or negative, and the optical character is positive. Where zoisite and epidote are associated in the same rock there is nothing in their mode of occurrence to suggest other than an equilibrium relationship between the two minerals.

Diopside is also widely distributed in the calc-silicate rocks and is the main constituent of narrow dark-green bands and lenses that occur here and there among the marbles. In the rocks of Kellard Point it is almost colourless in thin section, but elsewhere is typically pale-green or occasionally deep-green (e.g., No. 4631). In most slides the crystal outline is not sharply defined, but salite structure is often prominently developed. Rarely (e.g., No. 4630) it appears to be undergoing replacement by pale actinolitic amphibole, but on the other hand in sections where diopside and strongly coloured hornblende are closely associated the two phases appear to coexist in equilibrium (e.g., Nos. 4592, 4639).

Equant rounded or irregularly bounded grains of scapolite are plentiful in many rocks, particularly those from the Deep Cove waterfall (Fig. 7). It approximates, in all cases where birefringence was measured,* to mizzonite, but appears to vary within wide limits within a given slide. Thus in No. 4583a ($\gamma - \alpha$) was estimated as 0.023, 0.029, 0.030, 0.038 in different grains, corresponding to variation between about 45% and 80% meionite. [Note that these percentages are only approximate, since the birefringence of scapolite is affected also by the amount of sulphur and (OH) present in the molecule (Winchell, 1933, pp. 295, 296)]. A single measurement in No. 4590 gave $(\gamma - \alpha) = 0.030$. There is a marked tendency for scapolite to occur plentifully in rocks containing zoisite. In sections where it is associated with basic plagioclase (e.g., Nos. 4583, 4590) the two minerals appear to be in equilibrium, but in one section of spotted marble (No. 4667) some of the larger spots of scapolite are in process of replacement by clinozoisite, slender prisms of which have grown radially inward from the margins.

Nodular masses of pink garnet-rock 2 mm. to 5 mm. in diameter are not uncommon in the marbles from near Hall's Arm, but are rare at Kellard Point and were not observed at the head of Deep Cove. Sections show coarse granular aggregates of pinkish-yellow or pale-pink garnet sometimes with abundant inclusions of calcite (No. 4620) associated with clinozoisitic epidote, diopside, quartz and

* Birefringence was determined in all cases by the standard Universal-stage method described by Nikitin (1936) using adjacent grains of quartz for comparison.

accessory sphene. The epidote often contains plentiful vermicular grains of intergrown quartz (Nos. 4621, 4625) or calcite (No. 4620) and tends to build up marginal zones incompletely surrounding the aggregates of garnet grains. Garnet of similar appearance is a minor constituent of a large diopside-epidote-scapolite nodule (No. 4631) from the same locality and is concentrated conspicuously towards the outer portion of the specimen. No. 4676 (Kellard Point) shows a rather different assemblage, small granular patches of garnet (5 mm. in diameter) being scattered through a marble that contains abundant rounded crystals of diopside in addition.

Green or greenish-brown hornblende is for the most part confined to the hornblende-plagioclase bands already described. Where these adjoin diopside-bearing rocks, an assemblage consisting essentially of hornblende, andesine, diopside and epidote minerals is developed at the junctions (Nos. 4591, 4592). A similar but more complex association of minerals, including calcite, microcline and quartz in addition, characterises the calc-gneisses (Nos. 4662, 4664) locally interbedded with feldspathic gneisses south of the entrance to First Arm. A small streak consisting entirely of dark olive-green hornblende cuts sharply across a section of diopside-epidote rock (No. 4639) from the Hall's Arm locality. A pale-green actinolitic amphibole, occurring in rather stout prismatic crystals with a tendency to sieve structure, is associated with epidote and sphene in several specimens of highly sheared leucocratic rocks rich in plagioclase (Nos. 4630, 4640, 4671). It seems to have replaced a more strongly coloured amphibole, relicts of which are still preserved in No. 4630. Actinolite is certainly secondary after hornblende in No. 4662 and after diopside in No. 4630.

Plagioclase approximating to acid andesine (Ab_{60} to Ab_{70}), though sometimes rather more calcic or more sodic than this range, is a member of several assemblages. Highly calcic varieties were noted in two sections, viz., Nos. 4590 (bytownite) and 4583 (anorthite). In the latter section observations on lamellar twins having the twin axis perpendicular to the composition plane give the following co-ordinates for the pole of the twin axis with respect to the axes of the indicatrix: 46° (Z), 65° (Y), 57° (X). Two solutions are possible: if the twin axis is \perp (010) the composition is $Ab_5 An_{95}$; if the twin axis is \perp (001) the composition $Ab_{20} An_{80}$. The former alternative is confirmed by the axial angle as determined in adjacent twin lamellae [$2V = 74^\circ$ (—) and 76° (—)], and the birefringence ($\gamma - \alpha = 0.011$) as observed in comparison with adjacent grains of quartz.

Microcline is present in a number of rocks from Deep Cove and in the two complex diopside-bearing calc-gneisses (Nos. 4662, 4664) from the southern side of the entrance to First Arm. In No. 4583 (Deep Cove waterfall) it is intricately intergrown with either anorthite or epidote. Rounded grains of orthoclase, perthite or microcline are also present in several marbles. This frequent presence of potash-feldspar in the calcareous rocks of Doubtful Sound is contrasted with its rarity in associated hornblendic and feldspathic gneisses, suggests that it is derived from reaction between dolomite,

calcite, silica and detrital sericite (cf. Tilley, 1920, p. 497) or from recrystallisation of authigenic orthoclase originally present in the parent limestones (cf. Daly, 1917, pp. 661-662; Spencer, 1925) rather than from magmatically introduced material. The latter possibility cannot be excluded, however, in view of the abundance of scapolite in these rocks and the presence of occasional dykes of granite-pegmatite in adjacent gneisses.

Sphene, sometimes coarse and idioblastic but more often in rounded or spindle-shaped grains of rather small size, is a minor constituent of most rocks. In some slides it is plentiful (more than 5% of the total composition), especially as inclusions in diopside (Nos. 4622, 4626, 4639) or epidote. Apatite is a frequent and pyrite a rare accessory mineral of the calc-silicate rocks.

DISTRIBUTION AND MUTUAL RELATIONS OF ROCK-TYPES.

For a distance of about a mile from the head of Deep Cove, hornblende-plagioclase-gneisses and hornblende-plagioclase-biotite gneisses are the main rocks exposed along the eastern shore. The plagioclase of these rocks is often more calcic than in similar gneisses further north (e.g., Ab₄₈₋₅₀ in No. 4569: Ab₅₅₋₆₅ in No. 4576). Oligoclase-quartz-gneisses are relatively unimportant in this section of the coast. Beneath the great waterfall at the head of the cove, minor lenses and bands of marble and calc-gneisses are interstratified with various types of hornblende-gneiss,* while about half a mile north of this a small band of epidote-quartz rock (No. 4578) was recorded. From a point about 1 mile to 1½ miles from the head of the cove to the southern end of Elizabeth Island, oligoclase-quartz-gneisses, often containing allanite and locally notable amounts of microcline (No. 4611) predominate over hornblende rocks. The rocks of Elizabeth Island and the adjacent eastern shore of the Sound, however, are strongly foliated hornblende-plagioclase-epidote-biotite-gneisses of a distinctive and uniform type (composition of plagioclase, Ab₇₅₋₈₀).

Hornblende-plagioclase-gneisses and hornblende-plagioclase-biotite-gneisses with subordinate oligoclase-quartz-gneisses are also the principal rocks exposed along the western shore of the Sound between the head of Deep Cove and the entrance to Hall's Arm. There are several noteworthy departures from this general association, however. At the small headland half a mile from the head, hornblende-plagioclase-biotite-gneisses containing abundant yellow-brown biotite are intimately associated with biotite-rich garnet-gneiss. The single specimen of hypersthene-bearing gneiss (No. 4564) from this locality is perhaps an incompletely metamorphosed norite, since the hypersthene has the lamellar structure peculiar to rhombic pyroxenes of the plutonic rocks (Hess and Phillips, 1938), and is a colourless variety differing greatly from the metamorphic pink hypersthene observed north of Hall's Arm. Retrogressive conversion of hornblende (or hypersthene) to actinolite and of garnet to chlorite is common in the rocks of this locality. A special phase of gneiss

* Strike 15° W. of N.; dip 30° to E.

occurring for some chains on either side of the first headland south of the entrance to Hall's Arm is a non-feldspathic hornblende-biotite rock (Nos. 4616-4617), often greatly sheared and apparently intrusive into the associated rocks. At the point marking the southern side of the entrance to Hall's Arm, and again on the small island nearby, marble and calc-gneiss are regularly interbedded with the normal hornblende-plagioclase-gneisses; the dip is regularly eastward at 40° to 45° (strike 10° W. of N.).

The rocks of Hall's Arm are mainly streaky well-foliated hornblende-plagioclase-epidote-biotite-gneisses (Nos. 4691, 4692, 4695) similar to those of Elizabeth Island. Along the north shore of the Arm for a distance of between one and two miles from the entrance, these rocks are associated with garnet-bearing gneisses, indicating a higher grade of metamorphism than was reached further south. This higher grade is maintained between Hall's Arm and Kellard Point, the typical associations being garnet-diopside-plagioclase, garnet-biotite-epidote-plagioclase-quartz, hypersthene-diopside-plagioclase; intimately associated with these are rocks consisting of the assemblages hornblende-plagioclase-quartz and plagioclase-quartz-biotite. The principal outcrop of calcareous rocks, phlogopite-marble accompanied by the usual calc-gneisses containing epidote, diopside, garnet, scapolite, etc., occurs at Kellard Point. The strike here is between 20° and 30° W. of N., with an easterly dip of about 25°.

Between Crooked and First Arms the coastal section was examined in less detail than elsewhere. Oligoclase-quartz-gneisses predominate and hornblende rocks are less abundant than elsewhere. Garnet-bearing types were not observed. Immediately south of First Arm calc-gneisses containing oligoclase, quartz, microcline, diopside, calcite, epidote and minor hornblende (Nos. 4662, 4664) are interbedded with the normal feldspathic gneisses which locally are intensely sheared.

The dominant rock at the one point where a landing was effected on Secretary Island (W. shore, 1 ml. N. of The Gut) is a strongly foliated hornblende-plagioclase-gneiss (No. 4658) containing minor biotite, epidote and very coarse sphene. Beach boulders include garnet-bearing types, however, while a rock collected by Dr P. Marshall (1907, p. 502) from Blanket Bay is a hornblende-oligoclase-gneiss with minor biotite, garnet, quartz and rutile.

Two rocks described by Professor R. Speight (1910, p. 262) from Wood Head, opposite the south-eastern end of Secretary Island, are a strongly schistose quartz-biotite-muscovite-gneiss, and a hornblende-plagioclase-gneiss with minor biotite, epidote, quartz and rutile.

CONDITIONS OF METAMORPHISM.

The persistent development throughout the whole of the region under consideration, of mineral assemblages containing hornblende and plagioclase (oligoclase to labradorite) shows that metamorphism was of a regional nature and was effected at high temperatures. Though maintenance of temperature may have been assisted by the

influence of subjacent granitic intrusions, the existence of which is suggested by the presence of occasional pegmatitic dykes, metamorphism of the Doubtful Sound gneisses is not to be regarded as essentially a contact effect. Shearing stress of a high order operating simultaneously with high temperature in reconstitution is indicated by the presence of foliated structures in most rocks, and, judging from the consistently shattered state of garnet porphyroblasts and the granulated and milled condition of quartz and feldspar in many rocks, must have been maintained to a late stage. Shearing seems to have ceased before the temperature began to fall, however, for retrogressive transformations like chloritisation of garnet and biotite and conversion of hornblende to actinolite are usually inconspicuous.

The general association of hornblende with plagioclase, biotite and epidote in varying proportions corresponds to the amphibolite facies of Eskola, or to a metamorphic grade at least as advanced as in the high-grade portion of the garnet zone of the Scottish Highlands (cf. Wiseman, 1934, p. 385). Possibly the grade may even be equivalent to that of the kyanite zone (cf. Harker, 1932, pp. 281, 283, 284), for, though Wiseman finds that in the Scottish epidiorites biotite disappears at the kyanite isograd, the biotite-rich members of the Doubtful Sound rocks obviously are richer in potash than the rocks studied by Wiseman.

Along the western coast of the Sound between Hall's and Crooked Arms the prevalence of gneisses containing almandine garnet and pyroxenes, though associated always with hornblende rocks in which these minerals are absent, is an indication of an even more advanced grade of metamorphism. The principal associations here are:—

Garnet-diopside-plagioclase (basic oligoclase) with minor hornblende and biotite.

Hypersthene-diopside-plagioclase (acid andesine) with minor hornblende.

Garnet-biotite-epidote-plagioclase-quartz with minor hornblende.

Plagioclase-quartz-biotite.

Hornblende-plagioclase-quartz.

On the map this locality is marked as a zone of garnet- and pyroxene-bearing gneisses; rocks containing garnet and hypersthene also occur locally at a point about half a mile from the head of Deep Cove on the western side. Assemblages containing garnet and diopside on the one hand or diopside and hypersthene on the other are characteristic of the highest grade of regional metamorphism, and, together with the coarsely crystalline condition of the rocks in question, indicate that reconstitution probably took place at great depth (cf. Harker, 1932, p. 284).

In a series of recent studies on the depth conditions governing the crystallisation of various metamorphic assemblages, D. K. Korjinsky (1936, p. 48; 1936a, pp. 279, 280; 1937, p. 393) has proposed

the following high-temperature facies arranged in order of decreasing depth for rocks without an excess of CaO and Al_2O_3 but saturated in SiO_2 :—

- (1) Hornfels facies
- (2) Almandine-hornfels facies
- (3) Eclogite facies
- (4) Garnet-amphibolite facies (almandine-hornblende-diopside)
- (5) Hypersthene-gneiss facies (almandine-hypersthene-plagioclase, with or without biotite; hypersthene-diopside-plagioclase, with or without biotite or hornblende).

The garnet- and pyroxene-bearing gneisses of Doubtful Sound would appear to correspond to a transition facies between (4) and (5) in Korjinsky's scheme.

The same writer (Korjinsky, 1937) has paid particular attention to the relation of calc-silicate assemblages to depth, and proposes the following scheme for calcareous and dolomitic rocks (listed in order of decreasing depth) :—

- (1) Larnite-merwinite facies
- (2) Gehlenite-monticellite facies (without larnite, merwinite, spurrite, etc.)
- (3) Periclase facies (without gehlenite and monticellite)
- (4) Wollastonite-grossularite facies (equivalent to garnet-amphibolite facies)
- (5) Facies characterised by absence of grossularite and wollastonite (equivalent to the hypersthene-gneiss facies). Characteristic minerals, as developed in the Aldan massif of Eastern Siberia, are calcite, diopside phlogopite, pargasite, hornblende, scapolite, andesine, chondrodite, clinohumite, spinel, quartz, potash feldspar, dolomite, forsterite.

The minerals characteristic of the calcareous rocks of Doubtful Sound are calcite, epidote, diopside, clinozoisite, zoisite, scapolite, plagioclase (oligoclase, andesine or rarely bytownite or anorthite), hornblende, phlogopite, microcline (or orthoclase), garnet,* quartz, sphene and dolomite (rare). The presence of a grossularite garnet and the great abundance of epidote minerals distinguish this general assemblage from that of Korjinsky's deepest zone, though of the epidote mineral zoisite at least is stable in deep-seated facies (Korjinsky, 1937, pp. 390, 391). On the other hand complete absence of wollastonite and the presence of quartz and calcite in mutual association are significant grounds for distinction from rocks of the wollastonite-grossularite facies and would appear to indicate crystallisation at a greater depth than these. The mineralogy of the Doubtful Sound rocks is thus apparently consistent with their crystallisation under conditions intermediate between those governing the facies listed above under (4) and (5) in Korjinsky's grouping.

*A member of the grossularite-andradite series containing appreciable iron; $\mu > 1.79$.

Retrogressive mineralogical changes are, on the whole, unimportant. They include replacement of garnet and biotite by chlorite, and crystallisation of pale tremolite or actinolite at the expense of green hornblende, diopside or hypersthene. In a few instances granular epidote appears to have formed by the breaking down of plagioclase or of hornblende during especially intense shearing.

STRUCTURE.

Vertical or steeply dipping joints, which are often very regular and may simulate bedding when seen from a distance, constitute the most conspicuous structural element of the gneisses of Doubtful Sound. Foliation is usually obvious on close inspection, but definite bedding is usually difficult to distinguish. Where both these structures are distinctly developed, as where marbles and hornblende-gneiss are interstratified, they appear to be parallel. Linear structures when present are usually difficult to record accurately unless the outcrops show well-defined foliation surfaces.

On both sides of Deep Cove and along the western shores of the Sound north of Hall's Arm, the dominant strike of the foliation is N.N.W. (330° to 360°). The dip is mainly eastward at angles of between 15° and 40° , but becomes relatively flat around the entrance to First Arm, and at the single point where landing was made on Secretary Island is definitely westward. Three sets of approximately vertical joints were observed, of which not more than two were recorded at any one locality: (a) striking between 235° and 275° , i.e., roughly perpendicular to the foliation; (b) parallel to strike of the foliation; (c) striking in a W.N.W. direction (295° to 300°).

Along both sides of Hall's Arm and the eastern shore of the Sound immediately opposite (in the vicinity of Elizabeth Island) the foliation strikes consistently in a N.E. direction (25° to 55°), and cross joints are prominently developed nearly perpendicularly to this (295° to 320°).

There is thus structural evidence of two deformations connected respectively with a N.N.W. and a N.E. tectonic axis. While the former axis is on the whole the more conspicuous of the two, the N.E. axis dominates the structure in the vicinity of Hall's Arm and Elizabeth Island; with it the W.N.W. cross jointing locally developed elsewhere should probably be correlated. The north-east trend of Hall's Arm itself is perhaps ultimately connected with the same tectonic direction. The dominant structures of the gneisses of Lake Manapouri have also been correlated with deformation across a tectonic axis having a prevalent N.N.W. trend but locally deviating to N.W. or N.E. (Turner, 1938, p. 132). The same tendency for local north-easterly deflection of a strike that generally trends slightly west of north has been recorded by Professor W. N. Benson for the slates, schists and gneisses of Preservation and Chalky Inlets (Benson, 1934, p. 420).

CORRELATION.

The gneisses of Doubtful Sound are continuous with the dominantly hornblendic gneisses of Lake Manapouri which the writer has recently correlated with Professor Park's Dusky Sound Series of

probable Palaeozoic age (Turner, 1937b, pp. 245, 246). Though the latter have as yet been only incompletely described (Marshall, 1907; Speight, 1910; Park, 1921, pp. 35, 36), they appear to resemble the more strongly metamorphosed of the Doubtful Sound rocks in many respects. For example, the mineral assemblages recorded by Professor Speight (*loc. cit.*) include the following from Dusky Sound: garnet-quartz-plagioclase-microcline-hornblende-epidote-biotite-sphene (D 1); garnet-diopside-plagioclase-quartz-hornblende with minor orthoclase, biotite and rutile (D 3) (also S 24 of Marshall, 1907, p. 501); hornblende-feldspar-rutile (D 15); quartz-microcline-biotite (D 16). The similarity confirms the correlation previously made for the Manapouri gneisses.

ACKNOWLEDGEMENTS.

The writer wishes to acknowledge gratefully his indebtedness to the Australian and New Zealand Association for the Advancement of Science for supplying a grant to defray the cost of field work. His thanks are also due to Drs H. L. Briggs and C. M. Focken for assistance in the field, to Professor W. N. Benson for advice and suggestions during laboratory investigations, and especially to Mr F. T. Seelye of the Dominion Laboratory for the nine chemical analyses that are published in this paper, and to Dr J. Henderson, Director of the N.Z. Geological Survey, who kindly made arrangements for carrying these analyses out.

LOCALITY LIST.

Specimen Number.	Locality.
4554-4568	W. coast of Deep Cove, $\frac{1}{2}$ mile from Head.
4569-4572	E. coast of Deep Cove, 1 mile from Head.
4573-4576	E. coast of Deep Cove, $\frac{3}{4}$ mile from Head.
4577-458 ¹	E. coast of Deep Cove, $\frac{1}{2}$ mile from Head (at the base of prominent bare bluff).
4582-4599	Great waterfall at E. side of Head of Deep Cove.
4600	E. side of Elizabeth Island, 1 mile from S. end.
4601	E. coast of Sound, opposite middle of Elizabeth Island.
4602-4603	Elizabeth Island, near South end.
4604-4608	E. coast of Sound, opposite S. end of Elizabeth Island.
4609	E. coast of Sound, opposite middle of Hall's Arm.
4610-4611	E. coast of Sound, opposite southern headland at entrance to Hall's Arm.
4612-4613	W. coast of Sound, 1 mile from Head.
4614-4617	W. coast of Sound, $\frac{1}{2}$ mile S. of entrance to Hall's Arm.
4618-4649	W. coast of Sound, at S. side of entrance to Hall's Arm.
4650-4653	W. coast of Sound, $\frac{3}{4}$ mile S. of entrance to Hall's Arm.

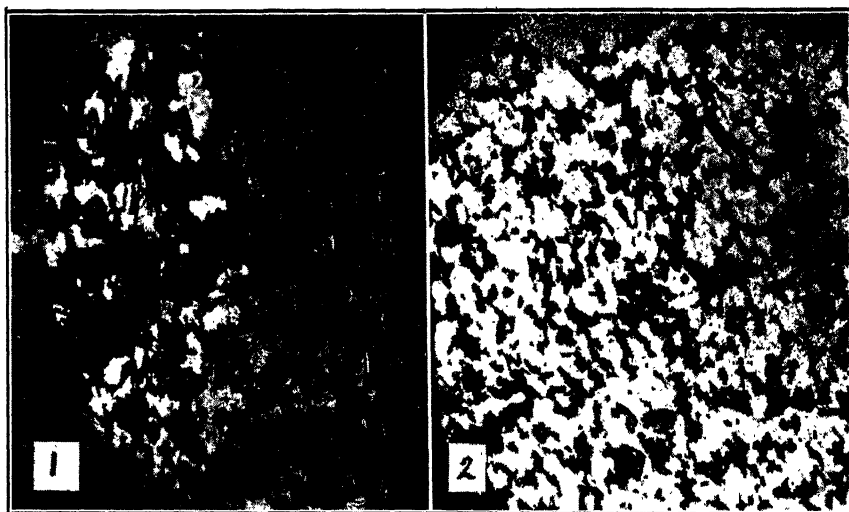


FIG. 1.—Hornblende-plagioclase-biotite-gneiss ("dioritic" type), No. 4599.

FIG. 2.—Fine-grained hornblende-plagioclase-gneiss, No. 4596.

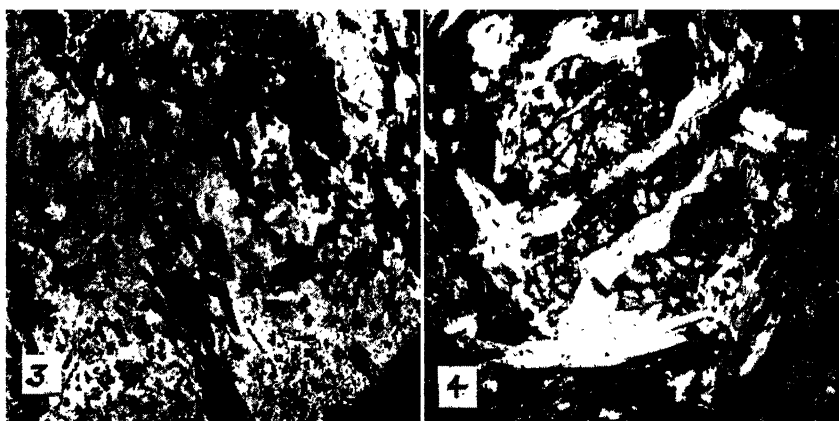


FIG. 3.—Coarse-grained hornblende-plagioclase-epidote-biotite-gneiss, No. 4601. The large sieved crystal in the top centre is hornblende; remaining dark crystals are mostly biotite.

FIG. 4.—Garnet-biotite-gneiss, No. 4554. A large central grain of garnet is surrounded and crossed by colourless chlorite; dark crystals around border of photograph are biotite.

All figures $\times 12$.

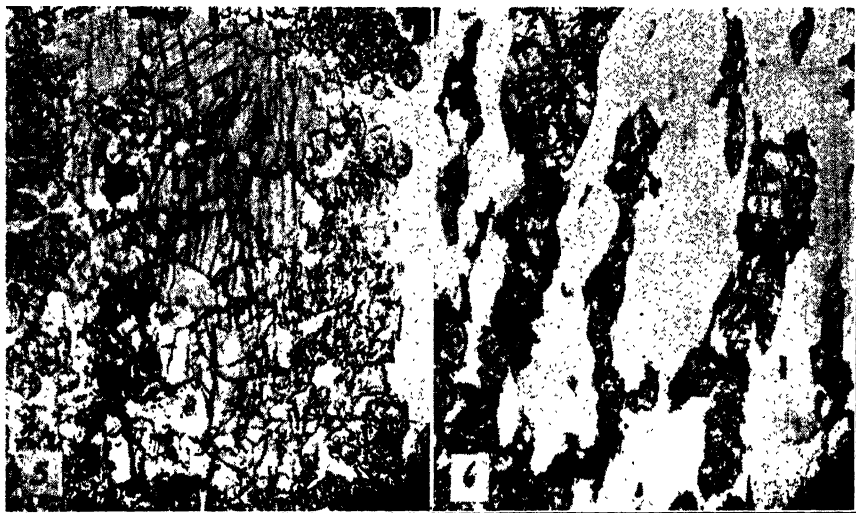


FIG. 5.—Diopside-garnet-gneiss, No. 4694. Diopside at centre (showing cleavage) surrounded at sides of photograph by garnet and interstitial quartz.

FIG. 6.—Diopside-hypersthene-gneiss, No. 4687. The colourless clear mineral is plagioclase.

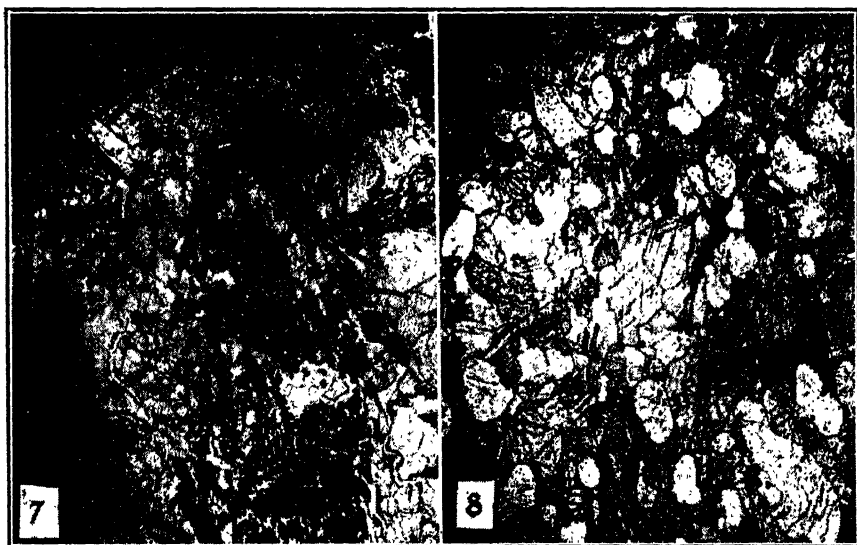


FIG. 7.—Prismatic zoisite surrounded by scapolite and quartz, No. 4678.

FIG. 8.—Marble with rounded grains of diopside, feldspar and scapolite.

All figures $\times 12$.

- 4654-4657 Boulders from beach, W. coast of Deep Cove, $\frac{3}{4}$ mile from Head.
- 4658 W. shore of Secretary Island, 1 mile N. of The Gut.
- 4659 N. side of entrance to First Arm.
- 4660-4664 S. side of entrance to First Arm.
- 4665 W. coast of Sound, $\frac{3}{4}$ mile N. of Crooked Arm.
- 4666-4678 Kellard Pt., $\frac{1}{2}$ mile inside Crooked Arm.
- 4679-4681 W. coast of Sound, 1 mile S. of Kellard Point.
- 4682-4684 W. coast of Sound, halfway between Kellard and Brigg Pts.
- 4685-4688 W. coast, $1\frac{1}{2}$ miles N. of Brigg Pt.
- 4689 W. coast, 1 mile N. of Brigg Pt.
- 4690 Brigg Point.
- 4691 N. shore of Hall's Arm, 1 mile from entrance.
- 4692-4694 N. shore of Hall's Arm, $1\frac{1}{2}$ miles from entrance.
- 4695 S. side Hall's Arm, $\frac{3}{4}$ mile from Head.

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The Significance of Tourmaline in the Otago Schists.

By C. OSBORNE HUTTON, M.Sc., Ph.D., F.G.S.,

N.Z. Geological Survey.

[*Read before the Otago Branch, September 13, 1938; received by the Editor, September 16, 1938; issued separately, March, 1939.*]

DURING a recent detailed petrographic investigation, tourmaline has been found to be a widely distributed and often abundant constituent of the metamorphic rocks of western Otago. In view of Goldschmidt and Peters' recent work (1932) the question has arisen whether we can justifiably consider this mineral to have formed as a result of permeating boron-bearing vapours originating from a deeply-buried granite batholith, or to be due to the boron content of the original unmetamorphosed sediments. The excellent work of these writers has shown that the boron content of clay sediments is often sufficient to bring about crystallization of tourmaline when these sediments suffer dynamic metamorphism and that it is not necessary to look to the younger acid intrusives for the origin of the boron. However, bearing this in mind, the writer feels that there is sufficient evidence to support the suggestion that the tourmaline present in the Otago schists owes its origin, at least in the majority of cases, to the presence of a granitic intrusion deep beneath the schist area.

The origin of the tourmaline may be considered in the light of the following facts:

(1) Tourmaline occurs in albite-epidote-chlorite or albite-epidote-actinolite-schists which lack micas or more than accessory amounts of quartz and hence appear to have been derived from basic igneous rocks.

(2) In an unusual green schist of tuffaceous origin, tourmaline is very abundantly developed as irregular patches in chlorite; it also occurs in sinuous lines in calcite and in groups of prisms concentrated within albite.

(3) Pale tourmaline is plentifully developed in a peculiar albite-muscovite-schist outcropping within a belt of crushed and pulverised rocks, the tourmaline-bearing schist itself not having suffered cataclasis.

(4) Veins of metallic sulphides occur throughout the region, and tourmaline has been observed in the adjacent rocks (Hutton, 1934).

(5) Granites, diorites and norites of the Fiordland Complex come to the surface 25–26 miles west of the head of Lake Wakatipu.

(6) Pale or completely colourless tourmaline is always developed, often abundantly, in a series of quartz-muscovite-piedmontite-schists.

(7) Quartz-albite-epidote- (+ muscovite) schists are not comparable to clay sediments in bulk composition or mode of origin.

(8) Scheelite occurs in varying amount in quartz veins throughout the Otago Schist Complex and Finlayson (1908) attributed its origin to solutions bearing tungstic acid ascending by way of lode-fissures from deep-seated magmas, largely granitic in character.

The presence of tourmaline in albite-epidote-chlorite or albite-epidote-actinolite-schists, in dense patches in a green schist of tuffaceous origin and in the albite schist in the shear zone would certainly seem to suggest pneumatolytic origin. The occurrence of clots of tourmaline forming sinuous lines in calcite is unusual, but Turner (1933, p. 224) described a comparable case in a rock from southern Westland, and considered pneumatolytic vapours responsible for the introduction of tourmaline. Nevertheless the possibility that the tourmaline is due to recrystallization and redistribution from a tourmaliniferous pebble of sedimentary origin must not be excluded, though if this were the case, it is difficult to understand why the mineral should occur in this curious manner.

The tourmaliniferous albite-muscovite-schist from the crushed zone has a curious bulk composition, for it is high in Na_2O , K_2O , Al_2O_3 and must contain appreciable B_2O_3 ; in the writer's opinion pneumatolysis alone can be held responsible for its unusual composition.

The widespread occurrence of tourmaline in most quartzofeldspathic schists is also believed to be due to permeating boron-bearing vapours, rather than to any original boron content of the sediments, for as pointed out in (7) above, their mode of origin and their composition is not comparable to that of clay sediments. Nevertheless it is true that these schists are derived from sediments which have originated by rapid disintegration of basic to intermediate rocks with some admixture of argillaceous and arenaceous impurities; but the boron content of the argillaceous material would have to be fairly high to account for the not inconsiderable quantity of tourmaline usually present.

In the piedmontiferous quartz-muscovite-schists, colourless tourmaline is a constant and important constituent, forming "nests" or strings of minute idioblastic prisms, sometimes completely confined within waterclear xenoblastic grains of quartz. The tourmaline in these schists has the properties corresponding most closely with those of elbaite, the refractive indices being $\alpha = 1.617$ and $\gamma = 1.637$; $\gamma - \alpha = 0.020$. The mineral is so plentiful in some thin slices that there would seem little doubt that it is the result of pneumatolysis. The production of piedmontite is, in the writer's opinion, closely associated with the presence of tourmaline in these quartz-muscovite-schists. The micaceous quartz-schists in this region can be divided into two groups:—

(1) Quartz-muscovite-garnet-schists without plentiful pale or colourless tourmaline, and

(2) Quartz-muscovite-piedmontite-schists with some manganese garnet but plentiful pale tourmaline.

If the only condition necessary for the formation of piedmontite was the presence of manganese, then why should it not be present in a quartz-muscovite-spessartite-schist without tourmaline? Clearly therefore, there appears to be a connection between the presence of piedmontite and much tourmaline. In recent work on several American occurrences of piedmontite (Lausen, 1927; Mayo, 1932; Short, 1933; Guild, 1935; Simonside, 1935) the authors all agree in believing that either hydrothermal solutions or proximity to igneous masses must be held responsible for the formation of this mineral. Furthermore H. von Eckermann (1936, p. 192) considers that close proximity to a sill of the Risberg granite is responsible for the development of crystals of manganese-epidote in a sericite-cordierite-schist in the Loos-Hamra Region. The present writer believes that the piedmontite in the western Otago schists is primarily a pneumatolytic mineral.

On the evidence of the scheelite veins in several localities in Otago, Finlayson (1908, pp. 119-120) put forward the suggestion that a batholith of a granitic type underlay the Otago region and there seems no good reason to doubt this view. An investigation of the south Westland area by Turner (1933) has shown that a granite mass becomes less deeply buried towards the west, the rocks becoming more and more metamorphosed till a zone of hornfels and contact gneisses is reached. Hence on this evidence alone it would appear reasonable to suppose that in the Central Otago-Wakatipu area this batholith is still present, but much more deeply buried. It is possible that apophyses of this intrusion have reached, or at least come very close to, the surface in Eastern Otago. Scheelite has been found at Saddle Hill, Barewood, Hindon, and Waipori. Furthermore, Turner and the present writer (1936, pp. 266-267) have found andalusite and kyanite in heavy residues of Tertiary sediments from the Dunedin area itself. Minerals such as kyanite, exhibiting very good cleavages, will not survive transportation over any great distance, hence this mineral at least would seem to have been derived from a nearby zone of intense metamorphism now buried under the Tertiary sediments or submerged off the present eastern shore-line. Further, it is clear that the watershed of streams that laid down these Tertiary beds must have included an area of thermally metamorphosed rocks, as indicated by the presence of andalusite.

To sum up, therefore, the present writer is of the opinion that in most cases the tourmaline present in the metamorphic rocks of the Otago area is due primarily to vapours and solutions given off from a granite batholith, the depth of burial of which becomes less and less as the western sea-coast is approached.

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PROCEEDINGS

OF

THE ROYAL SOCIETY OF NEW ZEALAND

MINUTES OF THE ANNUAL MEETING OF THE COUNCIL, 26th MAY, 1938.

The Annual Meeting of the Council of the Royal Society of New Zealand was held on Thursday, 26th May, 1938, at 10 a.m. in the Council Room, Victoria University College, Wellington.

Present: Professor W. P. Evans, President, in the chair.

Representing the Government: Mr. B. C. Aston, Professor E. R. Hudson, Dr E. Marsden;

Representing the Auckland Institute: Mr. G. Archey, Professor H. W. Segar;

Representing the Wellington Philosophical Society: Dr. H. H. Allan, Mr. F. R. Callaghan;

Representing the Canterbury Branch: Dr. F. W. Hilgendorf, Mr. E. F. Stead;

Representing the Otago Branch: Dr. F. J. Turner;

Representing the Hawke's Bay Branch: Mr. G. V. Hudson;

Representing the Manawatu Branch: Mr. M. A. Elliott;

Representing the Nelson Institute: Professor T. H. Easterfield;

Co-opted Member: Dr. P. Marshall.

Apologies: Apologies for absence were received from His Excellency the Governor-General, the Hon. the Minister for Scientific and Industrial Research, and Professor James Park (Otago Branch).

Members of Council: The President welcomed to the Council table Mr. G. Archey, Dr. H. H. Allan, Mr. F. R. Callaghan, and Dr. F. W. Hilgendorf, who took their seats for the first time, and thanked the retiring members—Professor Kirk, Professor Shelley, and Mr. C. M. Smith—for their services, making special reference to Professor Kirk, who had given valuable service to the Council over a period of twenty-three years, for two of which he had been President of the Society, and for the last four had been Honorary Librarian.

Presidential Address: The President then read his presidential address, first making reference to the deaths of Professor H. E. Armstrong, Sir D. Orme Masson, Mr. E. Meyrick, and Lord Rutherford, all Honorary Members of the Society, and to Sir Algernon Thomas and Bishop Williams, Fellows of the Society. The members rose in tribute to their memory.

The President congratulated Dr. F. J. Turner on obtaining a Sterling Fellowship at Yale College and Dr. P. Marshall on being elected a correspondent of the Académie des Sciences, Paris.

At the conclusion of his address the President was thanked and was asked to allow his address to be printed.

Hector Award: The recommendation of the Hector Award Committee was then read as follows:—

The Committee set up to make a recommendation on the award of the Hector Medal unanimously recommends the election of Bishop Herbert Williams, the last letter (that of Professor Elkin) reaching me an hour before I received news of Bishop Williams's death. In the circumstances I have to recommend a posthumous award, a course which has the assent of both Professor Elkin and Dr. Buck.

H. D. SKINNER,

Convener, Hector Award Committee.

On the motion of Professor Evans, seconded by Professor Easterfield, it was resolved that the recommendation of the Hector Award Committee be adopted.

It was decided to ask Mrs. Williams and her family how the medal should be presented.

On the motion of Dr. Marsden, seconded by Mr. Elliott, it was resolved that in the circumstances the medal be awarded without any prize.

Hutton Award: The recommendation of the Hutton Award Committee was read as follows:—

I beg to report that the Committee appointed to consider the award of the Hutton Medal has unanimously decided that the medal for 1938 should be awarded to Dr. David Miller.

P. MARSHALL,

Convener, Hutton Award Committee.

On the motion of Dr. Marshall, seconded by Professor Evans, the recommendation of the Committee was adopted.

Honorary Members: Dr. Marshall briefly outlined the qualifications of Professor A. F. A. Lacroix and Dr. Allan those of Professor C. Skottsberg, the two gentlemen nominated by Member Bodies for the vacancy in the Honorary Membership. On a vote being taken, Professor Skottsberg was declared elected.

Declaration of Vacancies: The President announced four vacancies in the Honorary Members' List caused by the deaths of Lord Rutherford, Sir D. Orme Masson, Professor H. E. Armstrong, and Mr. E. Meyrick. It was decided to fill the four vacancies at the next Annual Meeting.

Fellowship, 1938: The recommendation of the Fellowship Selection Committee was read as follows:—

A meeting of the Fellowship Selection Committee was held on Monday, March 7th. All the members were present except one who forwarded an apology. Full consideration was given to the ballot by the Fellows, to the scientific standing of the sixteen gentlemen who had been nominated for the two vacancies, and to the representation of the various sciences in the personnel of the Fellows.

Finally it was decided to recommend to the Council that the following two gentlemen should be elected as the new Fellows of the Royal Society of New Zealand:—

Dr. F. J. Turner, Lecturer in Geology, Otago University.
Mr. W. Donovan, Dominion Analyst.

P. MARSHALL, Convener.

7th March, 1938.

On the motion of Dr. Marshall, seconded by Dr. Marsden, the recommendation of the Fellowship Selection Committee was adopted.

Declaration of Vacancies in Fellowship: The President announced four vacancies in the Fellowship owing to the deaths of Lord Ruthven, Sir Algernon Thomas, Bishop Williams, and Mr. E. Phillips Turner.

Number of Fellows to be Elected in 1939: Dr. Turner moved and Professor Segar seconded that two be elected. Dr. Marshall moved as an amendment and Mr Hudson seconded that four be elected. On being put to the meeting, the amendment was lost. The motion was then put and carried.

Member Bodies' Reports and Balance Sheets: The following were placed on the table:—Auckland Institute for the year ending 31st March, 1938; Wellington Philosophical Society for the year ending 30th September, 1937; Canterbury Branch for the year ending 31st October, 1937; Otago Branch for the year ending 31st October, 1937; Nelson Philosophical Society for the year ending 30th September, 1937; Manawatu Branch for the year ending 10th November, 1937; Hawke's Bay Branch (balance sheet only) for the year ending 31st December, 1937.

Standing Committee's Report: The following report of the Standing Committee was taken clause by clause and adopted:—

REPORT OF THE STANDING COMMITTEE FOR THE YEAR ENDING 31st MARCH, 1938.

Meetings: Nine meetings of the Standing Committee were held during the year, the attendance being as follows:—The President (Professor W. P. Evans), Wellington, 9; Mr. B. C. Aston, Wellington, 8; Mr. M. A. Elliott, Palmerston North, 1; Mr. G. V. Hudson, Wellington, 9; Professor H. B. Kirk, Wellington, 6; Dr. E. Marsden, Wellington, 3; Dr. P. Marshall, Wellington, 7; Dr. W. R. B. Oliver, Wellington, 7; Mr. C. M. Smith, Wellington, 1; the late the Right Reverend Bishop Williams, Napier, 2.

Publications: The four parts of Volume 67 were published during the year and the material for Part 1 of Volume 68 was selected on the recommendation of the Hon. Editor by the Standing Committee at its meeting on the 23rd February.

In an endeavour to improve the quality of the printing of the *Transactions*, the printers have been instructed to print plates on one side only of the page.

A coloured plate to illustrate a paper on fruit characters of a *Coprosma* cross will be published in Part 1 of Volume 68.

Owing to increased costs the Otago Daily Times has intimated that it has been found necessary to increase the price of printing by 1/6 per page for text and plates and 3d per page for 100 separates. The question of calling for other tenders was referred on the 23rd March to the annual meeting for consideration.

Finances: On the 2nd October the President wrote to the Hon. Minister of Finance urging an increase in the annual grant to the Society. The Minister replied on the 11th October stating that the request would receive consideration and on the 9th December he wrote again advising that an additional amount of £150 had been voted, thus making the annual grant £750.

Library: The Library continues to be of great use to those engaged in scientific research, and many volumes have been posted to members in other centres. In this direction the reduced rate of postage for library books, approximately one-third of the ordinary rate, is much appreciated.

With the increased number of exchanges the accommodation in the Library is severely taxed.

Binding: No binding has been done during the year. The Christchurch binder who previously undertook the work apparently does not wish to resume, as he has not replied to letters, and it appears that the work will have to be done elsewhere. Quotations are being asked for from local firms.

Exchange List: On the recommendation of the Library Committee the Standing Committee agreed to the following applications for exchange:—

- Department of Scientific and Industrial Research, Wellington.
- Goteborgs Kungl. Vetenskaps och Vitterhetssamhalle, Sweden.
- Geologisch Instituut der Universiteit van Amsterdam, Holland.
- Instituto Botanico da Faculdade de Ciencias de Lisboa, Portugal.
- Mathematische Gesellschaft in Hamburg, Germany.
- Kaiserlich Leopold Carolin Deutsche Akademie der Naturforscher, Halle, Germany.
- Deutschen Museums fur Landerkunde in Leipzig, Germany.
- Naturwissenschaftliche Verein, Karlsruhe, Germany.
- Deutschen Kolonial und Uebersee Museum, Bremen, Germany.
- La Société Zoologique Tchecoslova de Prague, Czechoslovakia.
- Natural Science Society, Ljubljana, Yugoslavia.
- Institute of Marine Fisheries and Oceanography, Moscow, U.S.S.R.
- National Museum, Blomfontein, South Africa.
- Takeuchi Entomological Laboratory, Kyoto, Japan.
- Société des Naturalistes de Moscow, U.S.S.R.

Member Bodies' Reports: The following reports and balance sheets have been received from Member Bodies:—

- Wellington Philosophical Society for the year ending 30th Sept., 1937.
- Canterbury Branch for the year ending 31st October, 1937.
- Otago Branch for the year ending 31st October, 1937.
- Nelson Philosophical Society for the year ending 30th September, 1937.
- Manawatu Branch for the year ending 10th November, 1937.
- Hawke's Bay Branch for the year ending 31st December, 1937 (balance sheet only).

Manawatu Branch: On the 30th September the Standing Committee received advice that Mr. M. A. Elliott had been appointed to represent the Branch on the Council of the Royal Society of New Zealand in place of Dr. Cunningham, who had resigned.

The Late Bishop Williams: News of the sudden death of the Vice-President, the Rt. Reverend Bishop Williams, came as a great shock and was received with the deepest regret.

The Standing Committee held a special meeting on the 13th December, when the President, Professor Evans, feelingly referred to the death of the Vice-President, the Right Reverend Herbert W. Williams, M.A., Litt.D., F.R.S.N.Z., a past President and for many years a distinguished Fellow of the Society, and he moved:—

“That the Royal Society of New Zealand places on record its profound regret at the death of the Rt. Rev. Bishop Williams. His wide and accurate knowledge—so willingly placed at the disposal of others—his quick grasp of fundamental principles, his fearless criticism of wrong, his unfailing courtesy and happy disposition, made him a leader of men, and gained for him not only the respect but also the genuine affection of all those who were privileged to know him.

“By his death the Royal Society of New Zealand has lost one of its staunchest friends, and its members throughout the Dominion respectfully assure his widow and family of their heartfelt sympathy.”

Fellowship: On the 2nd September Member Bodies were asked to send in nominations to fill two vacancies occurring in the Fellowship. Sixteen nominations were received and were forwarded to the Fellows for selection. The result of the voting was placed before the Selection Committee and its recommendation will be considered at the annual meeting.

Honorary Members: On the 24th June, Member Bodies were advised that owing to the death of Dr. R. J. Tillyard there was a vacancy in the Hon. Members' List, and they were asked to forward nominations. Only three nominations have been received and an election will be held at the annual meeting.

Hector Award: It was found necessary to replace one of the members appointed at last annual meeting to the Hector Award Committee. The late Dr. Goddard had apparently been appointed under a misapprehension.

The President, with the approval of the Standing Committee, asked Professor Elkin, of the University of Sydney, to act on the Committee.

As Dr. J. R. Hosking, to whom the 1937 award was made, is still absent from New Zealand, the medal and prize have not yet been presented to him.

Hamilton Award: Mr. C. Osborn Hutton, to whom the Hamilton Prize was awarded at the last annual meeting, is also in England, and in the meantime he wishes the prize money to be retained by the Society.

Cockayne Memorial Fund: The fund now totals £260 9s 5d, the amount of £33 being contributed during the year, a portion of it in response to a second circular announcing the establishment of the Memorial Fund and its objects. The Standing Committee decided that the names of contributors be printed on a slip and distributed with a further appeal.

The Forest and Bird Protection Society asked the Society's co-operation in regard to the erection of a suitable memorial to the late Dr. Cockayne, and it was informed that the Society is establishing its own memorial and that the Wellington Philosophical Society and the City Council have practically finalised plans for the erection of a memorial headstone in the Otari Museum.

Carter Bequest: The draft of the Carter Observatory Bill embodying the proposals which were approved at last annual meeting was before the Standing Committee (confidentially) on the 23rd March. An assurance was given to members by the President that it contained only the proposals already approved and it was stated that copies of the Bill would be sent to members as soon as possible.

Hutton Grants: An application from Professor Benson and Dr. Turner for a grant of £50 for continuation of a geological survey of Dusky Sound and one from Dr. Turner for £15 to defray the cost of cutting oriented sections of Otago schists were recommended to the annual meeting for approval.

Medals: At the last annual meeting the Standing Committee was authorised to proceed with the alteration of the medals if funds were available, and at a meeting held on the 30th December the Standing Committee resolved to have the work commenced at once.

For historical purposes it was decided to have two Hutton medals struck from the dies before they were altered. These dies were shipped to England on the 29th October and were received by the firm of J. Pinches, who are now proceeding with the alterations.

Wild-life Control: Representations were made to the Standing Committee regarding the restrictions enforced by the Department of Internal Affairs in the issue of permits for the taking of certain birds.

The Wild-life Control Sub-committee considered the matter, but it came to the conclusion that it involved the whole question of wild-life control and the Society's recommendation that a separate Department be set up to administer wild-life.

The Standing Committee, in considering the report of the Sub-committee, decided to offer to the Department of Internal Affairs a competent committee of advice to assist in the administration of wild-life control in connection with the issue of permits. The Department replied that the "power to grant permits for the taking of birds subject to the Animals Protection and Game Act, 1921-22, is by that Act conferred on the Minister of Internal Affairs and this Department is not aware of any reasons for the setting up of a committee of advice as suggested."

National Organisation for Bush Conservation, etc.: The Wellington members of the Wild-life Control Committee met and considered the draft of the constitution of the proposed national organisation for bush conservation and amenity planting. This committee submitted some recommendations which were approved by the Standing Committee for transmission to the Department of Internal Affairs. On the 16th June the Under-Secretary wrote thanking the Standing Committee and stating that the recommendations would be placed before the Interim Committee for its consideration.

Pacific Science Association: On the 15th June a letter dated 29th April, 1937, from the Chairman of the Hold-Over Committee which made it evident that an invitation to hold the Sixth Pacific Science Congress in New Zealand in 1940 would be welcome, was considered.

It was decided that the President and Vice-President should interview the Government regarding the matter, but as both the Prime Minister and the Minister of Finance were in England, it was considered advisable to wait until their return. On the 2nd August the President placed the position before the Prime Minister, the Minister of Finance, and the Minister for Scientific and Industrial Research who, while being favourably disposed to the proposal, were unable to give a decision until it had been considered by Cabinet. Subsequently a cable was received from the Hold-Over Committee stating that the University of Hong Kong, endorsed by the Government, wished to know the attitude of the Hold-Over Committee regarding a proposal to hold the Congress in Hong Kong in August, 1938. This cable lent urgency to the attitude of the New Zealand Government regarding the proposal for 1940 and the President again approached the Prime Minister, who replied on the 23rd September that in view of the numerous commitments already made for the Centennial year, 1940, it was regretted that no undertaking could be given that the necessary grant would be available to defray the cost of the Congress, although the Government would be pleased to consider assistance during a later year.

A cable, later confirmed by letter, was thereupon dispatched to the Hold-Over Committee conveying this information and stating that the Royal Society would readily acquiesce in whatever decision the Hold-Over Committee came to regarding the proposal to hold the Congress in Hong Kong.

N.Z. Science Congress.—As instructed by the last annual meeting, the Standing Committee ascertained the opinion of Member Bodies regarding the continuation of biennial congresses. The consensus of opinion was that it was desirable that they be continued, but most of the societies pointed out that it

was Wellington's turn to hold the next Congress. The Wellington Philosophical Society, however, did not wish to hold the Science Congress until 1940, when it could be held as part of the centennial programme.

At the time there was the possibility that the Government would be prepared to invite the Pacific Science Association to meet here in 1940, so it was decided to defer action until the Government's decision was made known. As the decision was not known until the end of September the Standing Committee considered it too late to organise a Congress for 1938 despite renewed representations from the Otago Branch.

On the 23rd March the Standing Committee considered a further letter from the Otago Branch urging that Member Bodies be asked to express an opinion on the desirability of holding a Congress in 1939 and their opinion as to the most suitable place.

The Standing Committee was of opinion that the next Congress should be held in 1940 in Wellington, but it agreed to ask Member Bodies and the matter will be decided at the annual meeting.

International Scientific Union: On the 19th May Mr. G. T. Railton reported that he had been able to attend some of the meetings in London and visits arranged for the General Assembly of the International Scientific Union and that he was very grateful for the opportunity of representing the Royal Society of New Zealand.

At this General Assembly it was agreed, following on the discussion of a resolution proposed by the Royal Academy of Sciences of Amsterdam to appoint a Committee on Science and Its Social Relations, and all bodies adhering to the Union have been asked to appoint a correspondent interested in the activities of the Committee who would act as a link between the adhering body and the Committee.

Member Bodies were accordingly asked to suggest a suitable correspondent for this office, the appointment to be made at the annual meeting.

The Late Lord Rutherford: News of the death of Lord Rutherford was received with the deepest regret.

At a meeting of the Standing Committee held on the 27th October, the President spoke feelingly of his early association with Lord Rutherford in Canterbury and his friendship of over 45 years' standing. Professor Evans said that though Lord Rutherford's death might seem untimely, yet he had accomplished more in his comparatively short span than many would have done in a century. All might feel proud that he had done so much, so well, and, with it all, still remained a kindly, modest, generous man who was not only an inspiring leader but also a great gentleman.

He moved the following resolution, which was carried in silence:—

"The Royal Society of New Zealand expresses its profound regret at the unexpected death of its most distinguished Fellow, Ernest, Baron Rutherford of Nelson, O.M., M.A., D.Sc., Ph.D., LL.D., F.R.S., F.R.S.N.Z.

"The Society feels that by his death the world of science has lost its most brilliant experimenter, one whose name will be inscribed on the short roll of those who, from time to time in the history of human endeavour, have been permitted to enter the more secret chambers of Nature and pass on the knowledge there gained to their less gifted fellows. The Society, with which Baron Rutherford was so long and so closely connected, recognizes also that it has lost an honoured friend, and its members desire to assure his widow, Lady Rutherford, of their sincere sympathy."

The foregoing resolution was published in the leading papers throughout New Zealand.

A wreath from the Royal Society of New Zealand was arranged for.

A memorial notice written by Dr. Marsden, together with a bibliography of Lord Rutherford's scientific papers compiled by Dr. C. M. Focken in association with Mr. J. Harris, Librarian of Otago University, will appear in Volume 68, Part 1.

Scientific Bibliography: The Canterbury Branch suggested that the Royal Society should prepare a bibliography of scientific books and papers published in New Zealand as part of the Centennial commemorations to be held in 1940. The Standing Committee thought this would be rather cumbersome in a "History of New Zealand" and the matter could be given serious consideration only if the suggestion came from the Centennial Committee.

Loder Cup: The Society was asked to forward nominations for this year's Loder Cup, and the Standing Committee appointed a sub-committee which recommended that the Forest and Bird Protection Society be nominated for the 1937 Loder Cup.

On the 23rd February the Standing Committee was notified that the Cup had been awarded to the Auckland Institute and Museum in association with the name of Miss L. M. Cranwell.

Storage of Books.—At the request of Dr. Scholefield, the General Assembly Librarian, the stocks of *Transactions* which for many years had been stored in the Assembly Library basement were removed to our own storeroom. The work entailed a cost of £12 1s 5d as the room had to be cleaned and the stocks sorted and shelved in sequence.

Union List of Periodicals: The New Zealand Library Association's Committee on the Union List of Serials wrote asking the Society's opinion on a proposal that the Library Association should assume the responsibility for the completion and publication of a Union List of serials scientific and otherwise and asking that the material at present being worked upon for the revision of the present Reference List be handed over for this purpose. All interested institutions would be asked to share in the initial cost of the Union List and it was hoped to obtain a grant from the Government or the Carnegie Corporation to publish it.

The Standing Committee discussed the proposal, but considered that a Scientific Reference List would be of more practical value to the Society's members and less costly, and it was decided to continue with its compilation.

Arising from the Report:—

(a) *Carter Bequest:* The President stated that he had seen a copy of the Carter Observatory Bill and that it was in accordance with the proposals approved by the last Annual Meeting.

In reply to a question by Mr. Archey, the President stated that the Bill provided for the upkeep of the Observatory.

(b) *Wild Life Control:* Mr. Stead took exception to the wording of a letter received from the Department of Internal Affairs in reply to the offer by the Society of a competent committee of advice regarding the issue of permits. After some discussion Mr. Stead and Mr. Archey were asked to prepare a resolution on the matter.

Subsequently, on the motion of Mr. Archey, seconded by Mr. Stead, it was resolved: "That this Council reaffirms its opinion that the administration of the Animals Protection Act in regard to permits is not sufficiently based on scientific considerations, and considers it essential that a competent committee of advice and adjudication on this matter should be set up and consulted on all applications received, and on other matters of wild life control."

(c) *Bush Conservation and Soil Erosion:* Dr. Marsden drew attention to the urgent need for action in regard to the prevention of soil erosion and destruction of bush, and after notice was given

the following motion, moved by Dr. Marsden, seconded by Mr. Stead, was carried:—

“ That the Government be urged to set up a Royal Commission with scientifically competent personnel to enquire into and report on the measures necessary for the preservation of the vegetation of New Zealand, with special reference to forests, and the incidence, control, and prevention of land erosion.”

(d) *Scientific Bibliography*: Dr. Hilgendorf said the Canterbury Branch had considered that scientific publications in New Zealand were now so numerous that an index to them was very necessary, and it was thought that if the Centennial Committee were approached it might be willing to print such a bibliography if the actual work were undertaken by the Royal Society. He moved and Mr. Stead seconded the following motion, which was carried:—

“ That the Royal Society of New Zealand approves the proposal to prepare a bibliography of New Zealand scientific books and papers as a Centennial memorial of New Zealand science and that the Standing Committee approach the Executive of the Centennial Historical Committee to find if it will print the Bibliography if it is prepared by the Society. That in the event of the Executive's assenting, the Standing Committee make arrangements with the leaders in the various branches of science to prepare relative sections of the Bibliography.”

(e) *Union List of Periodicals*: Dr. Hilgendorf stated that the Standing Committee's decision to continue with the preparation of the Scientific Reference List had been discussed at the last meeting of the Council of the Canterbury Branch. He said the intention of the Library Association's Sub-committee on the Union List was to obtain contributions up to £200 from interested institutions to cover the initial cost of the more comprehensive Union List and then apply to the Carnegie Corporation or to the Government for a grant to publish the List.

After some discussion it was decided that the Society's proposal to publish a smaller scientific list was more practicable, and on the motion of Mr. Archey, seconded by Dr. Hilgendorf, it was resolved that the Standing Committee be authorised to apply to the Carnegie Corporation of New York for a small grant to enable the revised list of scientific periodicals to be printed.

Hon. Treasurer's Report and Balance Sheet and Statements: On the motion of the Honorary Treasurer, Mr. M. A. Elliott, the following report, balance sheet, and statements were adopted.

HONORARY TREASURER'S REPORT.

The balance sheet for 12 months ending 31st March, 1938, shows a credit of £937 11s 6d as compared with £719 11s 6d on 31st March, 1937.

The annual grant from the Government has been increased from £600 to £750.

Sales of publications are £29 12s 5d as against £47 6s 4d in 1937, but that year was higher than usual.

Endowment Fund: This Fund was established in 1918 and now amounts to £1410. It is interesting to record that the first donation to the Fund was made by Sir Algernon Thomas, then Professor A. P. W. Thomas, a member of the Board of Governors of the then New Zealand Institute. It is desirable to assist the growth of this Fund as much as possible; this could be done by

either crediting the annual sales of publications, or by a transfer from the credit balance each year of a fixed amount. The finances would now permit of either course being followed.

Cost of Printing the Transactions: Volume 66, part 4, Volume 67, parts 1, 2, and 3, cost £487 5s 10d as against £480 18s 11d for four parts and the Index Volumes 52-63 the previous year. For the coming year the cost will be higher as the printers have stated that the charge will be 15s 6d per page for text and 16s 6d per page for plates as against 14s and 15s respectively last year.

Trust Funds: In the Carter Bequest £500 has been invested in 4 per cent. New Zealand Inscribed Stock, being purchased at £104 5s per cent.

This Fund now totals £12,883 6s 8d, but as soon as the Carter Observatory Bill is passed by Parliament, the then total credit will be paid over to the Carter Observatory Board of Trustees, and the Royal Society will consequently have no further interest in the administration of the Fund.

The Hector Fund revenue account shows a larger credit balance than usual as the prize money for 1937 has not yet been paid owing to Dr. Hosking's absence from New Zealand.

The Hector, Hutton, and Sidey Summertime Funds will be called upon to meet the expenses of the alterations to the medals in the coming year.

The Cockayne Memorial Fund has increased from £221 0s 11d to £260 9s 5d, but no contributions have been received since November, 1937.

As usual, the method of keeping the books and accounts reflects credit on the Secretary.

M. A. ELIOTT, *Honorary Treasurer.*

MEMBER BODIES.

The following schedule is prepared from the annual reports and balance sheets of Member Bodies:—

Auckland Institute—report not to hand.

Society.	Members.	Receipts.			Expenditure			Rule 3.
		£	s.	d.	£	s.	d.	
Canterbury Branch ..	139	147	8	9	148	15	10	Library and Museum
Otago Branch	186	402	9	4	400	12	10	Library
Wellington Phil. Society	195	306	2	0	151	0	5	Library
Hawke's Bay Branch	?	38	1	9	23	17	6	Library
Nelson Institute ..	?	1,064	0	1	1,037	7	10	Library
Manawatu Branch ..	53	39	1	11	22	15	2	20% subs. to R.S.N.Z.

THE ROYAL SOCIETY OF NEW ZEALAND.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING MARCH 31, 1938.

Receipts.

	£	s.	d.
Balance at 31st March, 1937	1,127	3	8
Annual Grant	750	0	0
Levy, Volume 66	199	7	0
Sales of Publications	29	12	5
Travelling Expenses: Member Bodies' share	14	7	6
Interest at Post Office Savings Bank	20	16	0
Favourable Exchange	1	2	8
Carter Bequest Interest	485	5	8
Hector Memorial Fund Interest	52	1	7
Hutton Memorial Fund Interest	61	8	11
Hamilton Memorial Fund Interest	1	19	7
Sidey Summer-time Fund Interest	24	13	2
Carter Library Legacy Interest	9	3	4
Cockayne Memorial Fund Interest	5	15	0
Endowment Fund Interest	51	0	0
Trust Funds paid through Bank of New Zealand	32	3	6
Transfer from Post Office Savings Bank to Bank of New Zealand	300	0	0
Transfer from Bank of New Zealand to Post Office Savings Bank	350	0	0
Refund from Carter Bequest to General Account	480	0	0
Refund from Trust Accounts to General Account	54	3	8

Expenditure.

	£	s.	d.
Otago Daily Times—66 (4), 67 (1, 2, 3)	487	5	10
Stationery	8	14	10
Salary (Secretary)	300	0	0
Charges (Insurance, Bank, etc.)	4	6	11
Subscription to International Scientific Union (three years) ..	21	7	9
Audit Fee	4	1	0
Petty Cash (Secretary, Editor, President)	12	15	6
Travelling Expenses	23	8	10
Travelling Expenses Carter Bequest Committee	2	10	0
Removing Books from Assembly Library to Storeroom	12	16	0
Carter Bequest Investment	524	2	6
Shipping Charges, Hutton Dies	1	1	8
Trust Funds transferred to Post Office Savings Bank	28	8	6
Transfer from Bank to Post Office Savings Bank	350	0	0
Transfer from Post Office Savings Bank to Bank of New Zealand	300	0	0
Funds credited direct to Post Office Savings Bank	640	7	3
Balance as under	1,328	17	1
	<u>£4,050</u>	<u>3</u>	<u>8</u>

	£	s.	d.	£	s.	d.
Bank of New Zealand	296	17	10			
Less Unpresented Cheques	28	8	6			
				268	9	4
Post Office Savings Bank				1,053	1	10
Cash in Hand				3	8	0
Petty Cash in Hand				3	17	11
				<u>£1,328</u>	<u>17</u>	<u>1</u>

THE ROYAL SOCIETY OF NEW ZEALAND.

STATEMENT OF LIABILITIES AND ASSETS AS AT MARCH 31, 1938.

Liabilities.

	£	s.	d.
Carter Bequest Capital Account	12,681	3	5
Hector Memorial Fund Capital Account	1,184	18	1
Hutton Memorial Fund Capital Account	1,314	8	6
Carter Library Legacy Capital Account	162	19	0
Sidey Summer-time Fund Capital Account	520	7	6
Hamilton Memorial Fund Capital Account	65	7	3
Endowment Fund Capital Account	1,265	3	5
Carter Bequest Revenue Account	202	3	3
Hector Memorial Fund Revenue Account	130	3	0
Hutton Memorial Fund Revenue Account	292	6	10
Carter Library Legacy Revenue Account	41	7	11
Sidey Summer-time Fund Revenue Account	61	11	11
Hamilton Memorial Fund Revenue Account	4	19	4
Cockayne Memorial Fund Revenue Account	260	9	5
Endowment Fund Revenue Account	144	17	4
Library Fund	126	1	10
Research Grants Fund	137	0	6
Balance of Assets over Liabilities	937	11	6
	<u>£19,533</u>	<u>0</u>	<u>0</u>

Assets.

	£	s.	d.
Inscribed Stock	17,108	14	11
Bank of New Zealand	268	9	4
Post Office Savings Bank	1,053	1	10
Cash in Hand	3	8	0
Petty Cash in Hand	3	17	11
Sundry Debtors	20	9	1
Carter Bequest—Post Office Savings Bank Account	198	8	3
Hector Memorial Fund—Post Office Savings Bank Account	130	3	0
Hutton Memorial Fund—Post Office Savings Bank Account	292	6	10
Carter Library Legacy—Post Office Savings Bank Account	41	7	11
Sidey Summer-time Fund	81	16	11
Hamilton Memorial Fund	70	6	7
Cockayne Memorial Fund	260	9	5
	<u>£19,533</u>	<u>0</u>	<u>0</u>

M. A. ELIOTT,

Honorary Treasurer.

The Audit Office, having examined the balance sheet and accompanying accounts required by law to be audited, hereby certifies them to be correct.

(Signed) J. H. FOWLER, *Controller and Auditor-General.*

THE ROYAL SOCIETY OF NEW ZEALAND.

REVENUE ACCOUNT FOR THE YEAR ENDING MARCH 31, 1938.

Expenditure.

	£	s.	d.
Printing Vol. 67 (1, 2, and 3)	388	2	10
Stationery	8	14	10
Salary	300	0	0
Subscription to International Scientific Union	21	7	9
Charges (Audit, Insurance, Bank)	6	10	5
Removing Books to Storeroom	12	16	0
Petty Cash	12	15	6
Travelling Expenses (Society's share)	9	1	4
Balance	937	11	6
	<u>£1,697</u>	<u>0</u>	<u>2</u>

Income.

	£	s.	d.
By Balance	719	11	6
Annual Grant	750	0	0
Levy, Vol. 66	199	7	0
Sales of Publications	20	19	6
Trust Funds Administration Expenses	5	19	6
Favourable Exchange	1	2	8
	<u>£1,697</u>	<u>0</u>	<u>2</u>
By Balance	£937	11	6

THE ROYAL SOCIETY OF NEW ZEALAND.

TRUST ACCOUNTS FOR THE YEAR ENDING MARCH 31, 1938.

Carter Bequest.

Dr.	£	s.	d.	Cr.	£	s.	d.
To Interest Invested	524	2	6	By Balance 31/3/37	245	10	1
Audit Fee	0	15	0	Interest	485	5	8
Administration Exs.	1	5	0				
Travelling Exs. Committee	2	10	0				
Balance	202	3	3				
	<u>£730</u>	<u>15</u>	<u>9</u>		<u>£730</u>	<u>15</u>	<u>9</u>
				By Balance	£202	3	

Hector Memorial Fund.

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee	0	5 0	By Balance, 31/3/37 ..	79	6 5
Administration Exs.	1	0 0	Interest	52	1 7
Balance	130	3 0			
	<u>£131</u>	<u>8 0</u>		<u>£131</u>	<u>8 0</u>
			By Balance	£130	3 0

Hutton Memorial Fund.

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee	0	5 0	By Balance, 31/3/37 ..	233	4 7
Administration Exs.	1	0 0	Interest	61	8 11
Shipping Charges —					
Dies	1	1 8			
Balance	292	6 10			
	<u>£294</u>	<u>13 6</u>		<u>£294</u>	<u>13 6</u>
			By Balance	£292	6 10

T. K. Sidey Summer-time Fund.

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee	0	5 0	By Balance, 31/3/37 ..	40	15 1
Administration Exs.	1	2 0	Interest	24	13 2
One-tenth Income to					
Cap.	2	9 4			
Balance	61	11 11			
	<u>£65</u>	<u>8 3</u>		<u>£65</u>	<u>8 3</u>
			By Balance	£61	11 11

Hamilton Memorial Fund.

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee	0	2 6	By Balance 31/3/37 ..	4	4 6
Administration Exs.	0	2 6	Interest	1	19 7
Half Interest to Cap.	1	19 9			
Balance	4	19 4			
	<u>£6</u>	<u>4 1</u>		<u>£6</u>	<u>4 1</u>
			By Balance	£4	19 4

Carter Library Legacy.

<i>Dr.</i>			<i>Cr.</i>		
	£	s. d.		£	s. d.
To Audit Fee	0	2 6	By Balance 31/3/37 ..	32	12 1
Administration Exs.	0	5 0	Interest	9	3 4
Balance	41	7 11			
	<u>£41</u>	<u>15 5</u>		<u>£41</u>	<u>15 5</u>
			By Balance	£41	7 11

*Cockayne Memorial Fund.**Cr.*

	£	s. d.
By Balance 31/3/37	221	0 11
Subscriptions	33	13 6
Interest	5	15 0
Balance	<u>£260</u>	<u>9 5</u>

Endowment Fund.

<i>Dr.</i>				<i>Cr.</i>			
		£	s. d.			£	s. d.
To Audit Fee		0	2 6	By Balance 31/3/37 ..		74	8 10
Administration Exs.		1	5 0	Interest		51	0 0
Balance		144	17 4	Interest P.O.S. Bank		20	16 0
		<u>£146</u>	<u>4 10</u>			<u>£146</u>	<u>4 10</u>
				By Balance		£144	17 4

Endowment Fund: Mr Elliott said that he considered it would be advisable to build up the Endowment Fund as much as possible and that each year a portion of the credit balance and the amount of the sales of publications should be credited to this fund. He moved and Mr Aston seconded and it was carried: "That the sum of £29 12s 5d arising from the sale of publications, and in addition the sum of £50, be transferred to the credit of the Endowment Fund."

Hon. Editor's Report: On the motion of the Honorary Editor, Dr. F. J. Turner, the following report was adopted:—

HONORARY EDITOR'S REPORT.

During the year ending March 31, 1938, a complete volume of the *Transactions*, comprising 515 pages, has been published: Part 1, June, 1937; Part 2, September, 1937; Part 3, December, 1937; Part 4, March, 1938.

The material for the first part of Volume 68 is in the printers' hands.

In all, thirty-seven manuscripts have been received during the year. Of these, twenty-two were published in Volume 67 (together with fifteen held over from last year), eleven are in the press and will appear in Part 1 of Volume 68, three have been approved by referees for inclusion in Part 2 of Volume 68, and one was returned to the author. I am glad to be able to report that in no case where a manuscript was approved by a referee was it necessary to reject or reduce it on account of length.

My work as Editor has been greatly lessened by the efficient co-operation of the Associate and Assistant Editors, Drs. Laws and Focken. It is with regret that I report the resignation of Dr. Laws from this position.

I am obliged to tender my own resignation, as I expect to be absent from New Zealand for fifteen months commencing in October.

F. J. TURNER.

Dr Turner announced that he would be absent from New Zealand for fifteen months and he regretted that it would be necessary to resign from the office of Honorary Editor. He paid a tribute to the work done by Dr. C. H. Laws and Dr. Focken, who had done a great deal to lighten the editorial work.

The resignation of Dr Focken as assistant Hon. Editor was also received. The resignation of Dr. C. H. Laws had been received earlier in the year.

On the motion of the President, seconded by Mr Elliott, it was resolved: "That the Council places on record its appreciation of the excellent work done by Dr. F. J. Turner as Hon. Editor of the Society's *Transactions* during the past three years, and also the valuable help given to Dr. Turner in his work by Dr. C. H. Laws, and Dr. C. M. Focken."

Printing Costs: It was reported that the cost of printing the *Transactions* had increased by 1/6 per page. Mr Elliott considered this a reasonable increase and Dr. Turner stated that it was over a year since Mr Harris, Manager of the Otago Daily Times Co., had told him it would be necessary to increase the price per page.

It was decided to continue in the meantime the printing arrangements with the Otago Daily Times Co.

In regard to a tender by Messrs Ferguson and Osborn which was placed before the meeting, it was resolved, on the motion of Professor Hudson, seconded by Mr Archey, that the matter be left in the hands of the Standing Committee.

National Art Gallery and Dominion Museum Board of Trustees: On the motion of the President the following report of the representatives on the Board of Trustees was adopted.

BOARD OF TRUSTEES OF NATIONAL ART GALLERY AND DOMINION MUSEUM
REPORT OF SOCIETY'S REPRESENTATIVES.

The Board of Trustees has met three times during the year ending March 31, 1938, and the meetings were attended by both your representatives.

The most important event of the year was a conference between the Board of Trustees and representatives of Local Bodies to consider a scheme for placing the funds of the Trustees upon a surer foundation.

The meeting was a very successful one and although subsequent movement by the Local Bodies represented has been slow and, to some extent, disappointing, it is reasonable to suppose that the funds available for upkeep and extension of Art Gallery and Museum will be considerably increased.

An educational officer has been appointed in connection with the Museum, and has already entered on his duties.

In the National Art Gallery several good exhibitions have been held, and others are being arranged for.

Your representatives are pleased to report that the meetings of the Board of Trustees are to be held at regular intervals in the future, and that a budgeting system is to be introduced for both Art Gallery and Museum.

P. MARSHALL
W. P. EVANS.

Honorary Librarian's Report: The following report of the Honorary Librarian, Professor Kirk, was adopted:—

REPORT OF HONORARY LIBRARIAN.

The President of the Royal Society of New Zealand:

The matter of most interest to the Council is, no doubt, the housing of the Library. It will be remembered that the Council decided that if a State Library of Reference should be established within a reasonable time it would hand over, on stated conditions, the control of its library to that Institution.

The present position so far as the State Library is concerned is that all information for instruction to the architects is being gathered and the Society is asked to send representatives to consult with the responsible Government officers on the main features of accommodation and arrangement that would secure to the members of the Society the fullest possible use of the Society's own books and those of the Library in general. It cannot, of course, be expected that such a building as is required for the State Library should be ready within two or three years and considering how much preliminary work has to be done it may well be more.

In the meantime, if the Society has to give up its present room, Victoria University College will find temporary accommodation for the Library in the new Biology building.

The Librarian, Miss Wood, has the greatest difficulty in finding room for the constant accession of new books coming in as a result of the increasing exchange list. Her management of the Library has been efficient to the utmost limit possible in the very difficult circumstances in which she works.

The Library Committee has not taken any action with regard to binding, as inquiries made by the Librarian have failed to show that satisfactory arrangements at reasonable cost could be made.

Faithfully yours,

H. B. KIRK.

The President stated that the National Library scheme was not very much further advanced, and as accommodation at Victoria College was severely taxed, it appeared that it would be necessary to remove the Library from the present room to the new Biology building, where a room had been set aside by Professor Kirk for the accommodation of the Library. It was approximately the same size as the present one, but it was hoped there might also be a smaller room available which could be used in the meantime. Professor Kirk made certain suggestions regarding the National Library project which were referred to the Standing Committee.

Arthur's Pass National Park Board: The following report of Professor Speight, representative on the Park Board, was adopted:—

ARTHUR'S PASS NATIONAL PARK.

Report of Representative.

The finances of the Board have benefited during the year by an additional grant of £250 made by the Government for the employment of permanent labour in order to maintain existing works in a proper condition and to establish new ones. Further tracks have been made and old ones substantially improved as a result of this assistance, and footbridges have been constructed over several streams. A new hut has been built on Kelly's ridge with the co-operation of the Grey Alpine Club, and a stone shelter erected near the summit of the pass for the convenience and protection of the public if caught by bad weather.

The area of the park has been increased by the inclusion of a block of country several thousand acres in extent in the valley of the Taramakau River and containing Lake Kaurapataka, a picturesque sheet of water with bush to the water's edge.

The question of plant protection throughout the park has received serious consideration. The prevention of depredations by passing motorists and others has been a matter of some difficulty, since with the present staff it is almost impossible to patrol effectively such an extensive area. The interests of botanists who wish to examine the vegetation of the park have been definitely safeguarded, and the procedure to be followed by those desiring specimens for scientific investigation has been fixed in conformity with Government regulations.

Further work has been carried out in connection with the Alpine garden near the railway station under the supervision of Mr. M. J. Barnett, Superintendent of Reserves to the Christchurch City Council. Specimens of over 120 species of plants occurring naturally in the park have been planted and are rapidly becoming established. In connection with this Alpine garden I have been requested by the Board to obtain an opinion from the Royal Society as to the advisability of restricting the plants in it to species actually growing in the park or of extending its scope so as to include Alpine plants occurring elsewhere in New Zealand, so that it may function to some extent as a National Alpine Garden. It might be pointed out that exotics are carefully excluded from the park wherever possible, and that the present site of the garden is readily accessible by road and rail, and lies at an altitude of just over 2400 feet above sea-level. Before proceeding any further, or approaching the Government for a grant towards its maintenance and supervision, the Arthur's Pass Board would be grateful for an expression of opinion from the Council of the Royal Society.

R. SPEIGHT.

In his report Professor Speight asked the Society to express its views as to whether the Alpine Garden being constructed in the Park should include in it alpine plants occurring elsewhere in New Zealand. Mr. Archey and Dr. Allan expressed the view that the Alpine Garden should be restricted to plants growing in the locality, and it was resolved on the motion of Mr Hudson to forward these views to Professor Speight.

Research Grantees' Report: The following reports presented by research grantees were adopted:—

REPORT OF RESEARCH GRANTEES.

Mr. B. C. Aston, who in 1926 took over from Dr. Malcolm a balance of £9 16s 7d for research on the Pukatea, reported on the 29th April, 1938, that since his last report (22nd April, 1937) nothing further has been published by workers, chief of whom is Dr. Fogg, of Hawera. He is desirous that those willing to examine the therapeutic action of Pukatea alkaloids should be given every opportunity to do so.

Dr. G. H. Cunningham, who in 1929 was granted £25 for a mycological survey of the Tongariro National Park, reported on the 20th April, 1938, that during the 1937-38 season he spent ten days camping on the north slope of Tongariro. Twenty-six collections of fungi were made, all of species obtained on previous occasions. It would appear that the record of species is about complete. He states that he will not feel satisfied on this point, however, until he has been able to make collections at monthly intervals over a period of one year. He will endeavour to arrange for time as soon as their laboratories are completed at Auckland. No expenditure was incurred during the year.

Waitemata Harbour Survey: On behalf of the Committee which in 1925 was granted £90 for a marine investigation, Mr. Powell reported on the 27th April, 1938, that owing to administrative duties, work during the year was restricted to three field trips. Gear to the value of £1 16s 6d was purchased to replace chain on the dredge and also to carry out minor repairs on the net. A paper on the littoral animal communities of the area is in course of preparation. There is an unexpended balance of £2 3s 6d in the grant.

HUTTON GRANT.

Messrs. R. A. Falla and A. W. B. Powell were in 1934 given a Hutton grant of £40 for research on the molluscan and bird fauna of the Sub-Antarctic Islands of New Zealand. On the 22nd April, 1938, Mr. Falla reported that the position regarding transport to the islands is unfortunately no better than has been indicated in previous reports. They have decided, therefore, with the permission of the Royal Society, to get as near to the Sub-Antarctic region as possible and work, at the end of this year, along the south coast of Stewart Island in the neighbourhood of Port Pegasus. The considerable Sub-Antarctic element in the fauna of this region would make such work accord very closely with the terms of the original grant.

Afternoon Roll Call: After the lunch adjournment the roll was called, all being present except Mr Elliott, who had asked leave in order to attend another meeting.

Tongariro National Park Board: On the motion of Dr. Marshall, representative on the Tongariro National Park Board, the following report was adopted:—

TONGARIRO NATIONAL PARK.

Report of Representative on Park Board.

Meetings: Three meetings of the Board have been held during the year. The following matters have been discussed:—

Planting of Mountain Flowers: It is, of course, known that no exotic plants may be introduced into the Park. It was agreed that no South Island plants should be introduced. It was decided to establish small gardens for the more

conspicuous plants of the Park, one of which should be near the National Park Chateau and another near one of the upper huts. There was unanimous agreement that great care should be exercised in obtaining specimens for the gardens and that none of the rarer plants should be disturbed.

Timber: A small amount of timber has been cut on the Board's property on the north slopes of Mount Tongariro. The Board visited the locality. Fires have destroyed some of the bush. Timber is still being cut on land adjacent to the Park and it is said that the value of the timber amounts to £25 per acre. All care is being taken to restrict timber cutting to land outside the area of the National Park.

Deer: Deer are being systematically destroyed. Difficulty arises because deer are constantly arriving from the Ruahine and Kaimanawa Mountains and other areas.

Fire: To prevent fire entering the Park from outside it is proposed to plant a fire-break of *Fuchsia* in certain places.

Stock: Legislation is being prepared in regard to stock trespass.

Roading: Various matters were considered in connection with roading.

Memorial: A deputation from Natives in regard to a memorial to Te Heuheu Tukino was received. A proposal will be made to construct an archway on the Bruce Road at the entrance to the National Park.

P. MARSHALL.

Ward Island Domain Board: The following report of the representative, Dr. Oliver, was adopted:—

WARD ISLAND DOMAIN BOARD.

Report of Representative.

No meetings of the Ward Island Domain Board have taken place during the past year, and no visits to the island have been made by members of the Board. It is reported that some of the trees planted by the Board are flourishing; also that the white-fronted tern is nesting on the northern end of the island. Evidently the breeding colonies of this tern are increasing in Wellington Harbour. Possibly those now nesting on Ward Island are the overflow of a colony on a small rock at Scorching Bay.

W. R. B. OLIVER.

Great Barrier Reef Committee: The following report of the representative, Dr. Oliver, was adopted:—

GREAT BARRIER REEF COMMITTEE.

Report of Representative.

The boring plant lent by the Victoria Mines Department was brought to Gladstone and shipped to Heron Island by the "Cape Leeuwin." It was landed in fine weather in May 11, 1937. Boring was begun on the 17th. By mid-July the bore had reached a depth of 672 feet, where the 5in. casing stuck in a hard band. The bottom length parted and all efforts to remove it failed. The material passed through was partly cemented coral fragments, becoming harder as the depth increased and with an increasing proportion of ingredients insoluble in acid.

The financial statement on November 19, 1937, showed a balance of £1041 2s 9d, of which £1000 was in bonds.

W. R. B. OLIVER.

New Zealand Institute of Horticulture: The following report of the representative, Dr. Oliver, was adopted:—

NEW ZEALAND INSTITUTE OF HORTICULTURE.

Report of Representative.

School of Horticulture: The Executive Council endorsed the scheme of the Curator of the Christchurch Botanic Gardens and decided to give its unqualified support thereto. At the annual conference held in Christchurch, January 27, 1938, it was resolved to request the Government's serious consideration of a scheme of Horticulture at Christchurch.

Conference on Bush Conservation, April 2, 1937: The President represented the Institute. Subsequently the draft regulations were considered by a Committee and proposed alterations were forwarded to the Government.

Mount Egmont National Park: The Taranaki District Council opposed a suggestion made by His Excellency the Governor-General, that a rock garden, including exotics, be made on Mount Egmont. Some years ago the Park Board passed a resolution against the planting of exotics in the park, and the annual Conference agreed to support this policy.

W. R. B. OLIVER.

Observatories Committee: The following report of the representatives, presented by Professor Burbidge, was adopted:—

OBSERVATORIES COMMITTEE.

Report of Representative.

There is not a great deal to report with regard to the activities of the Observatories Committee.

A few meetings, I think two, have been held in the last year, and the work has been continued as previously. Dr. Farr, as you are aware, resigned from the Committee. Professor Florance was appointed Chairman in his place. No appointment has yet been made to the position of Government Astronomer and Government Seismologist. Both these positions are filled by gentlemen acting in temporary capacities. It is understood that a more permanent solution may be possible when the Carter Observatory is established.

Mr. Wadsworth, Director of Apia Observatory, who has been absent on leave, returned during the year. There has been some activity in seismological publications, especially among the younger seismologists.

P. W. BURBRIDGE.

Liaison Committee: Professor Evans presented the following report of the Liaison Committee, which was adopted:—

REPORT OF LIAISON COMMITTEE.

The Committee, which was asked by the Council at the annual meeting, May 27, 1937, to continue in office for another year, has further considered the question referred to it, and can only repeat the main points of its earlier reports.

The Committee does not see how any definite bonds can be established between the Royal Society and other more or less kindred societies unless those societies have some real form of representation upon the Council of the Royal Society.

The Royal Society Act, 1933, makes no provision for such representation of other societies, and the Committee does not consider it wise, at present, to suggest legislation making such representation possible, especially if all the varied societies mentioned by some members are to be held eligible for such representation.

The Committee feels that when occasion arises for close co-operation with any particular society, or societies, it will be, as it has been in the past, an easy matter to arrange for such co-operation.

A majority of your Committee again urges the Council to consider adding to the *Transactions* the abstracts referred to in its last report (see p. 5, section 4, last par. report to annual meeting, 1937).

W. P. EVANS,

Convener.

In regard to the recommendation in the report that abstracts of scientific papers by New Zealand authors be included in the *Transactions*, it was resolved on the motion of Dr. Turner, seconded by Mr. Archey: "That the Council favours the general principle

of printing in the *Transactions* annual or biennial reviews of the progress of various branches of science in New Zealand, and that the matter be referred to the Standing Committee with power to act."

Hutton Grants: An application from Professor Benson and Dr. Turner for £50 in connection with a geological survey of Doubtful Sound was withdrawn on account of Dr Turner's proposed absence from New Zealand.

An application from Dr. Turner for £15 to defray cost of cutting oriented sections of Otago schists in connection with petrofabric studies of these rocks was approved.

N.Z. Science Congress: The replies of the societies regarding the date of the next Science Congress were considered. Dr. Marsden moved and Professor Hudson seconded that the Science Congress be held in Wellington in 1940. Dr. Turner moved as an amendment and Dr. Hilgendorf seconded that the Science Congress be held in Christchurch in 1939. The amendment was lost. The motion was then put and carried.

Subsequently, on the motion of Mr. Archey, seconded by Dr. Marsden, it was resolved: "That the Standing Committee be authorised to accept a Congress in May, 1939, if the Wellington Philosophical Society is willing to hold it at that time."

Committee on Science and Its Social Relations: Dr. Marsden was appointed to act as correspondent in New Zealand to the Committee on Science and Its Social Relations set up by the International Scientific Union.

Seal: The President drew attention to the fact that under the existing Rules the Society may use the present seal only until the date of the annual meeting of the Council in 1939. A good deal of discussion arose as to the legality of the present seal with the words "established 1867."

Professor Hudson moved and Professor Segar seconded: "That the present seal, after excising the words 'est. 1867,' be adopted." This motion was lost.

Finally, on the motion of Professor Evans, seconded by Dr. Marshall, it was resolved: "That the Council, having considered the proposal to alter the common seal of the Society, is of opinion that it is not desirable to depart from the historic design at present in use, and authorises the Standing Committee to take such steps as may be necessary to make legal the use of the present seal after 'the date of the annual meeting of the Council in 1939.'"

Professor Skottsberg's Visit: The President reported that the New Zealand University was very interested in the proposed visit to New Zealand of Professor Skottsberg and that it was willing to act conjointly with the Royal Society in issuing an invitation to Professor Skottsberg and had agreed to donate £25 for the cost of the visit.

Dr. Allan outlined the steps he had taken to raise funds for the purpose of bringing Professor Skottsberg to New Zealand and considered it would be fitting for the University and the Royal Society to extend the invitation.

Election of Officers: The election of officers was then proceeded with as follows:—President, Professor, W. P. Evans; Vice-President, Dr. P. Marshall; Hon. Treasurer, Mr. M. A. Elliott; Hon. Editor, Dr. J. Marwick; Hon. Librarian, Professor H. B. Kirk; Co-opted Member, Dr. P. Marshall; Trust Account Managers, Messrs. M. A. Elliott and B. C. Aston; Representative on N.Z. Institute of Horticulture, Dr. W. R. B. Oliver; Representative on Observatories Committee, Professor P. W. Burbidge; Representative on Great Barrier Reef Committee, Dr. W. R. B. Oliver.

Election of Committees:

Research Committee—The Standing Committee.

Hector Award Committee—Dr. P. Marshall (Convener), Professor R. Speight, Professor C. A. Cotton, Professor W. N. Benson, and Dr. J. Marwick.

Finance Committee—Mr. M. A. Elliott, Mr. B. C. Aston, and Dr. E. Marsden.

Library Committee—Professor Kirk, Professor Cotton, Dr. E. Kidson, and Dr. Oliver.

Fellowship Selection Committee—Professor Kirk (Convener), Mr. B. C. Aston, Dr. J. Henderson, Professor W. P. Evans, and Mr. G. Archey.

Wild Life Control Committee—Mr. B. C. Aston (Convener), Mr. G. Archey, Mr. E. F. Stead, Mr. R. A. Falla, and the President

Votes of Thanks: Votes of thanks were accorded to the President, to Victoria University College for the use of the rooms, to the Press, and to the Secretary (Miss Wood).

Date of Annual Meeting: The date of the next annual meeting was left to the Standing Committee to fix.

PRESIDENTIAL ADDRESS

I SHOULD like first to welcome the new members of our Council:—

Dr. H. H. Allan and Mr. F. R. Callaghan, representing the Wellington Philosophical Society; Mr. G. Archey, one of the representatives of the Auckland Institute; Dr. F. W. Hilgendorf, one of the representatives of our Canterbury Branch.

I hope that they may bring strength with their comparative youth, and that the new Wellington members will use every endeavour to take their places at the meetings of the Council's Standing Committee.

Mr. M. A. Elliott now takes a seat as the representative of our Manawatu Branch.

It is also fitting that I should thank the retiring members for their services, and make special mention of Professor H. B. Kirk, a Past President, for some time Hon. Librarian, and a valued member of the Council for no less than twenty-three years.

During the past year we have lost from our roll of Hon. Members:—Emeritus Professor Henry Edward Armstrong, Ph.D., LL.D., F.R.S. (elected 1927; died July, 1937); Emeritus Professor Sir David Orme Masson, M.A., D.Sc., F.R.S. (elected 1928; died August, 1937); Ernest, Baron Rutherford of Nelson, O.M., M.A., D.Sc., F.R.S., who was an original Fellow (elected 1909; died October, 1937); Mr. Edward Meyrick, B.A., F.R.S. (elected 1907; died February, 1938). And from our list of Fellows:—The Rt. Rev. Herbert William Williams M.A., Litt. D., Bishop of Waiapu (elected 1923; died December, 1937); Emeritus Professor Sir Algernon Phillips Withiel Thomas, M.A., F.L.S., F.G.S. (an original Fellow; died December, 1937).

These six deaths leave four vacancies in our Roll of Hon. Members, and three in our List of Fellows.

Professor Sir H. E. Armstrong was probably for several years "the most outstanding chemist of modern times."

A student under Hofmann and Frankland, at London, and later under Kolbe, at Leipzig, he became professor of chemistry at the London Institute, then at the City and Guilds of London Institute, and lastly (1884-1914) at the Technical College at South Kensington, now a part of the University of London.

He had a thorough knowledge of organic chemistry, was keenly interested in stereochemistry, and in the application of chemistry to biological and agricultural problems, but had an almost fanatical dislike for the modern mathematical side of inorganic chemistry.

He was far too deeply absorbed in teaching chemistry to do very much original work, but his papers on camphor, on sulphonic acids, on the nature of solutions, and (in collaboration with his son, E. F. A.,) on enzymes, are worthy of mention.

He was a great teacher, having that "gift which is as a hall mark," the gift of interesting his hearers, and, consequently, his pupils "not only attained distinction in the academic and industrial worlds, but also retained a lively interest in chemistry, an affection for their professor, and an outlook upon life that was widened and intensified by his stimulating personality."

Professor Sir David Orme Masson was the "acknowledged and distinguished leader of the chemical profession in Australia."

He founded the Australian Chemical Institute, and when, in 1932, that body was incorporated by Royal Charter, he became its first President.

The son of a professor of English literature in the University of Edinburgh, he had already distinguished himself by his work in organic chemistry, when, at the age of twenty-eight, he was appointed to the newly-created chair of chemistry in the University of Melbourne, where he and his eminent colleagues, Baldwin Spencer and T. B. Lyle, soon raised the University to a position of distinction in the field of scientific teaching.

His original papers, at first confined to purely organic chemistry, later became of a definitely physico-chemical nature, and show, not only a facility in mathematical treatment, but also a characteristic clarity of expression.

For thirty-seven years—more than a generation—his lectures on chemistry were considered models of simplicity and style.

His record was one of great achievement, and he has left many "treasured memories in the minds of those who knew him and owed so much to him."

The death of Baron Rutherford of Nelson was felt throughout the whole world, for his achievements had proved him the most brilliant experimenter of our time, and had assured him "a prominent and illustrious place in the annals of science."

In rapid succession an 1851 Exhibition Scholar from Canterbury College in the University of New Zealand, professor of physics at McGill University, Montreal, professor of physics at Manchester University, and Cavendish professor of physics at Cambridge University—where he proved himself a worthy successor to such men of genius as Maxwell, Rayleigh, and Thomson—he startled the scientific world by his work on radioactivity, by his revolutionary ideas on the constitution of the atom, and by his marvellous experiments on the transmutation of elements—experiments "which gave him, perhaps, his greatest renown."

"In his scientific work he was scrupulously honest; he did not delude himself or the world of science by unreliable experiments or deductions." He wrote and spoke with the charm of simplicity. "He

was devoted to his work, because he was enthusiastic in the cause of science, not because he thought of his own advancement," and for that reason he was always a great colleague, ready to give others their due credit, and careful that all who helped him should receive full recognition.

Speaking of him, Sir William Bragg, President of The Royal Society of London, said: "His noble contributions to knowledge have been the inspiration of innumerable workers and the foundation of a vast series of researches."

All who knew him hoped that his inspiration might be available for many a year to come (he was only sixty-six years old), but that was not to be, and "the world is left deeply poorer."

In Rutherford a great man passed, and for obvious greatness there is no substitute.

By the death of Edward Meyrick, entomological science has lost one of its most assiduous and capable independent workers.

Mr Meyrick was generally recognised as an authority on the Micro-Lepidoptera of the world, and had amassed one of the largest collections in existence. From 1877 to 1886 he was a schoolmaster at Sydney and at Christchurch, and later an assistant master at Marlborough College, England. During his sojourn in New Zealand he collected our native Lepidoptera with great vigour, visiting Mount Arthur, Arthur's Pass, Lake Wakatipu, and many other localities then very much less accessible than now. He has contributed to our *Transactions* every year from 1882 until 1937, and his published papers have been of inestimable value to our local entomologists. Although necessarily carrying on a most extensive and exacting correspondence, Mr Meyrick always found time to answer every inquiry in the fullest possible manner, and with great promptitude.

Of the many activities of Bishop Herbert W. Williams, whose sudden death in December last we all so sincerely regretted, a whole volume might well be written.

He was President of our Society in 1935 and 1936, and, at the time of his death, our esteemed Vice-President.

A devout and active churchman, a keen and wisely cautious ethnologist, a charming man of the world, and, above all perhaps, a loving, trusted friend of the Maori people, his loss was deeply felt by all sections of the community.

He has his reward, for of him we may surely use the words of Belloc:—

"He does not die who can bequeath
Some influence to the land he knows."

Professor Sir Algernon P. W. Thomas, one of the four foundation professors of Auckland University College, was for over fifty years an active member of the Auckland Institute and Museum, and for some time a member of the Board of Governors of the New Zealand Institute (now the Royal Society of New Zealand). He was actually the first to contribute to our endowment fund.

A scientist of very wide interests—mathematician, biologist, geologist—he did an enormous amount of work in the cause of education from the primary grade to that of the University, work which was fittingly recognised by his elevation to a knighthood not long before his death.

The Auckland district in particular has good cause to hold him in grateful memory.

On behalf of the Council I congratulate Dr F. J. Turner upon his election to a "Sterling Fellowship" at Yale University, feeling confident that by his work abroad he will add to the reputation he has already gained.

The acceptance of a fellowship necessitates, however, his resignation from the position of Hon. Editor, a position which he has filled so ably during the past three years.

I feel sure that every member of the Council will agree with me when I say that the Society's *Transactions* have benefited greatly by his labour of love.

I also congratulate our co-opted member, Dr. P. Marshall, upon his election as one of the foreign correspondents of the "Académie des Sciences," of Paris.

This distinguished body may be said to date from 1666, and, in spite of suppressions and re-establishments, has had so many great men among its members that "to trace the fortunes of this Academy would be to write the history of the rise and progress of science in France."

I now wish to refer briefly to some remarks made by your last President, the late Bishop Williams, in his presidential address in May, 1936.

You will remember that he suggested it might be advisable to provide rules for the election of various committees, and some of you may have wondered why no action had been taken in the matter.

The reason is that Bishop Williams himself was not quite certain about it (he made no further reference to it either in his next address or at meetings of the Standing Committee) and in our last talk together he told me that he had concluded it was probably best to leave well alone. He now felt that it might, at times, be impossible to follow the letter of a rule demanding definite conditions for membership of a particular committee, and rules which had to be broken might well be worse than none.

I said I also saw difficulties in connection with this particular proposal, and considered the constitution of the Award and Fellowship Committees already sufficiently safeguarded.

We therefore decided that for the present it was wise to proceed no further.

His other suggestion, that the election of an Hon. Treasurer should be made obligatory, was not referred to.

I hope that these few remarks make the position clear.

I turn now to the general position of the Society, or rather, to the aims of the Society, for while its position depends entirely upon the vigour and honesty with which it pursues its aims, those aims can be fairly definitely stated.

I therefore raise the question whether the time has not now arrived for the Society to alter the original statement of its objects—a statement no doubt eminently suited to its day—and follow more closely in the steps of other bodies bearing the honourable title “Royal Society,” especially the oldest and most illustrious, viz.—The Royal Society of London, by restricting itself to the sciences?

Whether we care to acknowledge it or not we are already, in reality, a society for the furthering of scientific knowledge, and, whether we like it or not, we do not receive, and will not receive, for insertion in our *Transactions* those literary and artistic papers which, so it seems to me, find a much more natural resting place in publications almost entirely devoted to literature and art respectively.

It is useless to deny the revolution which has taken place during the last few decades. Science itself has so rapidly extended its bounds that a division of its vast territory into smaller units was inevitable, as was also the tendency for those of literary or artistic bent to follow paths of their own making.

We may regret these effects of revolution—no revolution has ever been satisfactory to all parties—but no regrets can bring back the past, and what the present demands is work.

Upon its work, and upon that alone, rests the future position of the Society, and its strength in work depends neither on its Council nor on its Fellows, but upon the strength of its various branches, and the strength of any such branch depends upon the honest endeavours of its individual members.

If every member of each branch does, to the best of his ability, his share of the needed work, the Society as a whole will never have cause to feel its position other than secure.

I have said that the Society's main object is the advancement of scientific knowledge. All such advance depends upon work, although it is now the fashion to use the word research.

Not long ago a speaker at any scientific meeting found it a “popular and an easy thing to attack the Government for its almost entire neglect of scientific research.” The Great War, however, brought about a complete change, and scientific research is now being encouraged in almost every direction. In New Zealand our Department of Scientific and Industrial Research, with its increasing family of quasi-industrial laboratories, is an instance of this happy change,

and the present Government is to be congratulated upon the gradual unfolding of a more generous policy towards the D.S.I.R. and its requests for funds.

I feel sure that any sum thus expended upon genuine scientific research, especially research connected with the industrial problems of the Dominion, will be fully repaid. Indeed, I would go further and say that in these eventful days when material actually fights against material—the synthetic against the natural, and the newer synthetic against its older rival—properly co-ordinated scientific research is our safest form of insurance against economic disaster, and that the Government which refuses to pay the necessary premiums is as foolish as the individual who scorns to insure his wooden house against the risk of fire.

The premiums demanded may at times appear large, but in comparison with the bonuses subsequently declared they are generally very small.

This last statement may seem exaggerated, for I know that in certain quarters it is fashionable to sneer at research departments as (a) costing a lot, and (b) never returning a dividend, and for that reason I should like to give you just one instance, chosen from many, of the way in which industrial research repays its cost.

England, as you know, is poorly supplied with effective sources of water-power, but is richly endowed with available coal of high rank.

Electricity is now being used more and more as a vehicle for transmitting power to a distance, and hence the conversion of the heat energy of coal into electrical energy has become to England a matter of vital importance.

The practical efficiency of the conversion is, moreover, capable of exact measurement.

A few years ago it required an average of 3.7lb of coal to produce one unit of electricity. The last report of the Electricity Commissioners shows that an average of only 1.48lb of coal is now required to produce each unit of electricity.

This increase in efficiency—an increase largely attributed to the work of the Electrical Industries Research Association during the past two years—represents an economy of approximately 17,000,000 tons of coal per year, and if the coal is delivered to the various power houses at an average cost of 7s 6d per ton, the annual saving amounts to £6,375,000; actually the saving in 1936-37 was over £7,000,000.

It is not easy to estimate, except very roughly, how much money was spent in directly bringing about this result, as the production of electricity by the use of coal was one only of the many problems studied, but the TOTAL amount spent by the British Department of Scientific and Industrial Research during the year mentioned (October 1, 1936, to September 30, 1937) was under £600,000—the official figure being £583,230.

It thus appears that, even if no further advance is made, either in total production or in conversion-efficiency, the WHOLE of the money spent by the department on ALL its researches was repaid (and will continue to be repaid) more than ten and a-half times a year by this single result. In these days of low interest the dividend is not a bad one, and we need not ask why *Nature*, in an editorial, remarks: "It is doubtful whether any other expenditure in the national budget brings in anything like the same return as the £600,000 expended by the Department of Scientific and Industrial Research."

What thus happened in England has happened in other countries, also, and will happen in New Zealand if those to whom our industrial problems are entrusted are given the needed equipment and the necessary time.

The critics who cry out at the expense connected with research, also complain of the time needed by research to reach fruition, and for the lag between discovery and application are apt to blame the scientist. They would be better employed in trying to alter Nature's law that between action and reaction there must be a lag.

It is true that this lag between scientific discovery and economic application shows a tendency to become less than it used to be, but it will always be there, and should be allowed for.

May I, in fairness to our New Zealand workers, stress the fact that in a country like our own, depending chiefly, as it does at present, upon agricultural and pastoral research, the time lag is almost certain to be greater than in a country such as England, where the mechanical industries are of paramount importance. The routine of a field differs widely from that of a factory, and cannot be changed in a day.

The story of the past fifty or sixty years shows clearly that those who seek benefits at the hands of science must be prepared not only to work, but also to wait; it shows, with equal clearness, that waiting brings its reward.

In judging the results of a research institution it must, moreover, never be forgotten that much of the less spectacular work, such as the systematic collection of information, the careful testing of materials, and the establishment of standards, is certainly of no less importance than work leading to developments which catch the public eye. Indeed, "without the foundation of knowledge thus accumulated," it is more than doubtful whether the important advances already made by research institutions would have been possible.

These advances have, indeed, been made in such rapid succession, and have had such far-reaching results, that there are those who would now apply a brake.

It would, of course, be useless to attempt to bar further progress, for the attempt could only end in failure, but it might be both.

possible and wise to use foresight and caution in releasing to industry any discovery which seemed likely to cause immediate hardship, whether by rendering obsolete some expensive and hitherto effective plant, or by writing off, as it were in a day, the whole value attaching to accumulated stocks.

In future, perhaps, some department as yet unborn may be able to perform this difficult, if not invidious, task.

But I must return to the present.

May I sum up this section of my address by saying that to me it is evident that, in spite of the criticisms to which they are subjected, criticisms sometimes (as we have lately heard) expressed in contemptuous but very silly words, our New Zealand research institutions, both those established by the Government and those under private control, are doing good work, and are honestly endeavouring "to substitute facts for appearances, and demonstrations for impressions."

The subject of research, whether undertaken by independent workers or by teams of a departmental laboratory, leads directly to that of publication, for surely, to use Swedenborg's quaint words, "whatever is worthy to be known should by all means be brought into the great and general market of the world."

In the matter of publishing the results of research the Royal Society of New Zealand has done its share right well. Its *Transactions*, now about to enter on their sixty-eighth volume, constitute a worthy record of work in pure and applied science, and, in conjunction with the publications of other scientific and technical institutions of the Dominion, render valuable service to the community, and do much towards providing material without which some of our industries could hardly flourish; "industry keeps up-to-date or goes into liquidation."

Now and then one hears the question: What does the Royal Society do with its annual grant? The answer is a very simple one, namely: Gives it to the printers.

Our duly audited accounts show that since the year 1918 the Society has received in grants from the Governments of the time a total sum of £18,850, and that during the same period the sums spent in actual publication of its *Transactions* and *Bulletins* totalled £16,935. No less than 89.8 per centum of the grants received was thus used in publishing the results of original work.

The accounts further show that in five of the nineteen years included in the above statement the Society spent on printing an amount considerably greater than the grant received, and who shall say that the expenditure was not justified?

Were it not for the levy imposed upon individual members of the Society's branches the work of publication could not be carried on so effectively as it now is. The Society has undoubtedly been severely handicapped during the past few years by the shortness of

its funds, and it is extremely pleasant to know that conditions are now somewhat better. I take this opportunity of once more thanking the members of the Cabinet for restoring a portion of our former statutory grant, and assuring them that the money so placed in our hands will be spent to good purpose.

While speaking of the publication of scientific papers in New Zealand may I be allowed to express the satisfaction I feel, not only as your President, but also as a chemist, at the recent decision of the New Zealand Institute of Chemistry that it was not desirable to increase "the number of publications dealing with original work." The Journal of the N.Z.I.C. is now to be essentially "a quarterly publication devoted to the interests of the chemical profession."

The very limited circulation of our *Transactions* among chemists living overseas is now almost the only bar—though certainly a serious one—to the publication therein of original researches in chemistry, and if a suggestion to be made later in your Liaison Committee's report is adopted we shall soon have in our volumes reasonably full abstracts of all chemical and physical papers by New Zealand workers quite independently of the publications in which they may have appeared originally. The publication of these abstracts will, of course, mean both work for the abstractors and expense for the Society, but both the work and the expense seem warranted.

The past record of the Royal Society of New Zealand with regard to publication is good; the present members of the Society have the opportunity to make it even better.

In conclusion, I wish to thank the members of the Standing Committee and the Secretary for doing much towards making my year's work as President both pleasant and light.

Visit of PROFESSOR Dr. KARL SKOTTSBERG

PROFESSOR SKOTTSBERG, Director of the Gothenburg Botanical Gardens, Sweden, is a recognized authority on taxonomic botany and phyto-geography. Especially is he renowned for his studies on the biological relations of Austral and Pacific lands, and his work has been of deep interest and vital importance to New Zealand botanists, as was emphasized by the late Dr. L. Cockayne. An example is his recent monograph on the genus *Astelia*. His services to New Zealand were recognized by his election as an Honorary Member of the Royal Society of New Zealand. The Professor had long desired to visit New Zealand to see for himself a flora and vegetation on the history of which he had thrown so much light.

Hearing that Professor Skottsberg would be working on the bog vegetation of the Hawaiian Islands, local botanists thought that he might be induced to extend his itinerary to include New Zealand. The idea was warmly taken up by the Royal Society of New Zealand and by the Senate of the New Zealand University. Local branches of the Royal Society and the University gave keen support, so that funds sufficient to enable the visit to be made were soon raised. Great interest was expressed by the New Zealand Government and a free railway pass over all lines was willingly granted.

A formal invitation was sent by the Royal Society and the University Senate, which was gratefully accepted by Professor Skottsberg. Unfortunately, circumstances would allow of only a five weeks' stay. The Professor arrived in Auckland on October 17th, 1938, and was welcomed by Dr. H. H. Allan on behalf of the President of the Royal Society and the Chancellor of the University Senate, and by representatives of the local bodies interested.

Two lectures were delivered in Auckland and botanical excursions made under the guidance of Mr. T. L. Lancaster, of Auckland University College, and Miss L. M. Cranwell, of the Auckland Museum. These included visits to the Waitakere Ranges, Rangitoto Island, Rotorua, Rainbow Mountain, the Tongariro National Park, and Mount Hauhungatahi.

Two lectures were delivered in Wellington, and the Professor was welcomed on behalf of the Government by the Honorable P. Fraser. An excursion of several days was made to the Taranaki Mountains, under the guidance of the staff of the Botany Division, Plant Research Bureau, and shorter local visits were made. The Professor twice examined the Otari Open Air Plant Museum, and laid a wreath of native plants, collected by himself, on the grave of his friend of many years, the late Dr. Leonard Cockayne. A luncheon talk was delivered before the Rotary Club on "Nature Preservation in Sweden," and an examination made of the coastal vegetation of Wellington Harbour.

Besides lecturing in Christchurch, Professor Skottsberg opened the Cockayne Memorial Garden, to be devoted to native plants, and visited the botanical gardens and various private gardens. A special visit was paid to his friend, Mr. R. M. Laing, our veteran algologist. In addition to local excursions visits were made to Arthur Pass and Mount Torlesse, under the guidance of Messrs. C. E. Foweraker, of the Canterbury University College, and J. W. Calder, of the Canterbury Agricultural College. A luncheon talk on "Experiences in South America" was given to the Graduates' Association.

After lecturing in Dunedin, Professor Skottsberg visited the Botanical Gardens and several private gardens noted for their collections of native plants. Under the guidance of Messrs. Geo. Simpson and J. Scott Thomson he ascended Mount Maungatua, and made an excursion of several days, including visits to Lakes Manapouri, Te Anau and Wakatipu, and the Eglinton Valley to the Homer Saddle. The return journey was made via Central Otago and the Waipori Gorge.

On his return to Auckland the Professor lectured before the students of the Training College on the "Distribution of Antarctic Vegetation," and to the Auckland Botanical Society on "The Hawaiian Islands." This was illustrated by a beautiful series of colour photographs taken during his work in the islands. Further local excursions were made, including one to Paremoreno to see *Loxosoma Cunninghamii*.

The lectures delivered before the branches of the Royal Society and the University Colleges were on the following topics: The Biological Relations of the Juan Fernandez Islands; Along the Cordilleras of Chile; The Vegetation of Subantarctic America. These were also open to the general public. The large audiences that attended will long retain vivid memories of the vegetation and geography of the regions described, illustrated as they were by a remarkably fine series of slides.

Professor Skottsberg also gave several shorter talks, delivered radio addresses on "Easter Island" and "Paradise Lost: a Chapter in the History of Antarctica," and eagerly sought opportunities of discussions with local botanists and students. A typical example of his eagerness to help was his hour's stay with an isolated young enthusiast at the Homer Saddle.

The Professor collected practically every flowering plant that came under his notice, and the long hours spent in caring for his treasures was a lesson not likely to be forgotten by those who observed it. His genial personality, his command of the English tongue, his readiness to help, his capacity for work and his profound knowledge of the subjects dealt with will long inspire those who came under his influence.

The list of those who so freely rendered help is too long for citation, but each and every one has already felt that he has been well repaid by the success of the visit, and to each and every one Professor Skottsberg tenders his sincerest thanks.

H. H. A.

APPENDIX.

LIST OF AWARDS.

AWARD OF THE HECTOR MEMORIAL MEDAL AND PRIZE.

1912. L. Cockayne, C.M.G., Ph.D., F.R.S., F.L.S., F.R.S.N.Z.—For researches in New Zealand botany.

1913. T. H. Easterfield, M.A., Ph.D., F.R.S.N.Z.—For researches in chemistry.

1914. E. Best, F.R.S.N.Z.—For researches in New Zealand ethnology.

1915. P. Marshall, M.A., D.Sc., F.G.S., F.R.S.N.Z.—For researches in New Zealand geology.

1916. Lord Rutherford of Nelson, O.M., D.Sc., F.R.S., F.R.S.N.Z.—For researches in physics.

1917. C. Chilton, M.A., D.Sc., M.B., C.M., F.L.S., F.R.S.N.Z.—For researches in zoology.

1918. T. F. Cheeseman, F.L.S., F.Z.S., F.R.S.N.Z.—For researches in New Zealand systematic botany.

1919. P. W. Robertson, M.A., M.Sc., Ph.D.—For researches in chemistry.

1920. S. Percy Smith, F.R.G.S., F.R.S.N.Z.—For researches in New Zealand ethnology.

1921. R. Speight, M.A., M.Sc., F.G.S., F.R.S.N.Z.—For work in New Zealand geology.

1922. C. Coleridge Farr, D.Sc., F.R.S., F.R.S.N.Z.—For research in physical science and more particularly work in connection with the magnetic survey of New Zealand.

1923. G. V. Hudson, F.E.S., F.R.S.N.Z.—For researches in New Zealand entomology.

1924. D. Petrie, M.A., F.R.S.N.Z.—For researches in New Zealand botany.

1925. B. C. Aston, F.I.C., F.R.S.N.Z.—For the investigation of New Zealand chemical problems.

1926. H. D. Skinner, M.A., F.R.S.N.Z.—For research in ethnology.

1927. C. A. Cotton, D.Sc., F.G.S., F.R.S.N.Z.—For researches in the geomorphology of New Zealand.

1928. D. M. Y. Sommerville, M.A., D.Sc., F.R.S.N.Z.—For his general mathematical work and particularly for his investigations in non-Euclidean geometry.

1929. G. M. Thomson, F.L.S., F.R.S.N.Z.—For researches on the acclimatisation of animals in New Zealand and on the natural history of New Zealand fishes.

1930. J. E. Holloway, L.Th., D.Sc., F.R.S.N.Z.—For researches in the life-histories of New Zealand *Pteridophytes*.

1931. W. P. Evans, M.A., Ph.D., F.R.S.N.Z.—For research in pure and applied chemistry.

1932. Te Rangi Hiroa (P. H. Buck), M.D., Ch.B (N.Z.), F.R.S.N.Z.—For researches in Maori ethnology.

1933. W. N. Benson, B.A., D.Sc., F.G.S., F.R.S.N.Z., and J. Marwick, M.A., D.Sc., F.R.S.N.Z.—For researches in New Zealand geology.

1934. G. E. Weatherburn, M.A., D.Sc.—For outstanding original work in mathematics, especially in the use of vector analysis.

1935. W. B. Benham, M.A., D.Sc., F.R.S., F.R.S.N.Z.—For original researches in New Zealand zoology.

1936. W. R. B. Oliver, M.Sc., D.Sc., F.L.S., F.Z.S., F.R.S.N.Z.—For research in New Zealand botany.

1937. J. R. Hosking, B.Sc., Ph.D.—For research in the chemistry of New Zealand plants.

1938. H. W. Williams, M.A., Litt.D., F.R.S.N.Z.—For researches in ethnology.

AWARD OF THE HUTTON MEMORIAL MEDAL.

1911. W. B. Benham, M.A., D.Sc., F.R.S., F.R.S.N.Z.—For researches in New Zealand zoology.

1914. L. Cockayne, C.M.G., Ph.D., F.R.S., F.L.S., F.R.S.N.Z.—For researches in the ecology of New Zealand plants.

1917. P. Marshall, M.A., D.Sc., F.G.S., F.R.S.N.Z.—For researches in New Zealand geology.

1920. J. E. Holloway, L.Th., D.Sc., F.R.S.N.Z.—For researches in New Zealand pteridophytic botany.

1923. J. A. Thomson, M.A., D.Sc., F.G.S., F.R.S.N.Z.—For researches in geology.

1926. C. Chilton, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., F.R.S.N.Z.—For his continuous researches on the amphipodous crustacea of the Southern Hemisphere.

1929. G. V. Hudson, F.E.S., F.R.S.N.Z.—For research in entomology.

1932. J. A. Bartrum, M.Sc., F.R.S.N.Z.—For researches in geology.

1935. G. H. Cunningham, D.Sc., F.R.S.N.Z.—For research in mycological botany.

1938. David Miller, Ph.D., M.Sc., F.R.S.N.Z., F.R.E.S., F.L.S.N.S.W.—For researches in entomology.

GRANTS FROM THE HUTTON MEMORIAL RESEARCH FUND.

1919. Miss M. K. Mestayer £10, for work on the New Zealand mollusca.

1923. Professor P. Marshall £40, for study of the upper cretaceous ammonites of New Zealand.

1927. Miss M. K. Mestayer £30, for research on brachiopoda and mollusca.

1928. Dr C. Chilton £50, for research on New Zealand and Antarctic crustacea.

1928. Dr J. H. Findlay £10, for research on New Zealand mollusca.

1932. Dr F. J. Turner £30, for geological expedition to south-west portion of Otago.

1932. Mr C. E. Christensen £25, for collecting hybrid plants at Hanmer.

1932. Mr L. C. King £20, for geological study of tertiary rocks at Awatere Valley, Marlborough.

1932. Dr O. H. Frankel £25, for cytological research.

1932. Waitemata Harbour Survey Committee £25, for ecological survey of Waitemata Harbour.

1933. Mr G. M. Thomson £30, for preparation of illustrated catalogue of New Zealand crustacea.

1933. Mr K. M. Ruddall £5, for zoological research on Little Barrier Island.

1934. Mr L. C. King £25, for geological research in the Marlborough District.

1934. Messrs R. A. Falla and A. W. B. Powell £40, for research on the molluscan and bird fauna of the Sub-Antarctic Islands of New Zealand.

1934. Dr. W. R. B. Oliver £50, for assistance in publishing a monograph on the genus *Coprosmia*.

1935. Dr P. Marshall £40, for purchase of microscope goniometer and field work in connection with mineral "tuhualite" of Mayor Island and the occurrence of the spheroidal granite of Karamea.

1935. Mr H. O. Service £4 10s, for geological research at the Bluff.

1936. Mr C. O. Hutton, £30, for field study of the Metamorphic and Intrusive rocks of the Lake Wakatipu region.

AWARD OF THE HAMILTON MEMORIAL PRIZE.

1923. J. G. Myers, D.Sc.

1926. H. J. Finlay, D.Sc., and J. Marwick, D.Sc., F.R.S.N.Z.

1934. L. C. King, M.Sc., Ph.D.

1937. C. O. Hutton, M.Sc., F.G.S.

AWARD OF THE T. K. SIDEX SUMMER-TIME MEDAL AND PRIZE.

1933. Lord Rutherford of Nelson, O.M., D.Sc., F.R.S., F.R.S.N.Z.
Special award to Mr G. V. Hudson, F.E.S., F.R.S.N.Z.

1936. Sir Leonard Hill, Kt., M.B., LL.D.

THE ROYAL SOCIETY OF NEW ZEALAND, COUNCIL FOR 1938-39.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND
INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED UNDER
THE NEW ZEALAND INSTITUTE ACT, 1903; CONTINUED UNDER THE NEW
ZEALAND INSTITUTE ACT, 1908; AND RECONSTITUTED UNDER THE ROYAL
SOCIETY OF NEW ZEALAND ACT, 1933.

HONORARY PATRON.

His Excellency the Governor-General.

COUNCIL.

EX OFFICIO.

The Hon. Minister of Scientific and Industrial Research.

GOVERNMENT REPRESENTATIVES.

Professor E. R. Hudson, B.Agr., B.Sc. (1937)
Dr. E. Marsden, C.B.E., F.R.A.S., F.R.S.N.Z. (1937)
Mr. B. C. Aston, F.I.C., F.R.S.N.Z. (1938)
Dr. W. R. B. Oliver, F.L.S., F.R.S.N.Z. (1938)

ELECTED BY MEMBER BODIES.

Auckland Institute	Mr G. Archey, M.A., F.Z.S., F.R.S.N.Z. Prof. H. W. Segar, M.A., F.R.S.N.Z.
Wellington Philosophical So- ciety	Dr. H. H. Allan, M.A., F.L.S., F.R.S.N.Z. Mr. F. R. Callaghan, M.A., F.R.E.S.
Canterbury Branch of the Royal Society of New Zealand	Dr. F. W. Hilgendorf, M.A., F.R.S.N.Z. Mr. E. F. Stead
Otago Branch of the Royal Society of New Zealand	Prof. J. Park, F.G.S., F.R.S.N.Z., M.Inst.M.M. Dr. F. J. Turner, F.G.S., F.R.S.N.Z.
Hawke's Bay Branch of the Royal Society of New Zealand	Mr G. V. Hudson, F.E.S., F.R.S.N.Z.
Nelson Institute	Prof. Sir Thos. H. Easterfield, M.A., Ph.D., F.I.C., F.C.S., F.R.S.N.Z.
Manawatu Branch of the Royal Society of New Zealand	Mr. M. A. Elliott.

CO-OPTED MEMBER.

Dr. P. Marshall, M.A., F.G.S., F.R.G.S., F.R.S.N.Z.

OFFICERS FOR THE YEAR 1938-39.

PRESIDENT: Prof. W. P. Evans, M.A., Ph.D., F.R.S.N.Z.
 VICE-PRESIDENT: Dr. P. Marshall, M.A., F.G.S., F.R.G.S., F.R.S.N.Z.
 HON. TREASURER: Mr M. A. Elliott.
 HON. EDITOR: Dr. J. Marwick, M.A., F.R.S.N.Z.
 HON. LIBRARIAN: Professor H. B. Kirk, M.A., F.R.S.N.Z.
 HON. RETURNING OFFICER: Professor H. W. Segar, M.A., F.R.S.N.Z.
 SECRETARY: Miss M. Wood, Royal Society of New Zealand, Victoria University College, Wellington, New Zealand.

MEMBER BODIES.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Auckland Institute	Mr G. Archey, Institute and Museum, Auckland	June 10, 1868
Wellington Philosophical Society	Mr J. T. Salmon, Dominion Museum, Wellington.	June 10, 1868
Canterbury Branch of the Royal Society of N.Z. ..	Mr E. W. Hullett, Wheat Research Inst., Chch.	October 22, 1868
Otago Branch of the Royal Society of New Zealand	Mr H. D. Skinner, Otago Museum, Dunedin.	October 18, 1869
Nelson Institute	Mr O. B. Pemberton, Cawthron Institute, Nelson.	December 20, 1883
Hawke's Bay Branch of the Royal Society of New Zealand	Mr W. Goodwin Ball, Hawke's Bay Gallery and Museum, Napier.	March 31, 1875
Manawatu Branch of the Royal Society of New Zealand	Mr S. J. Bennett, 25 Worcester Street, Palmers-ton North.	1935

FORMER MANAGER AND EDITOR

(Under the New Zealand Institute Act, 1867.)

1867-1903.—Sir James Hector, M.D., K.C.M.G., F.R.S.

PAST PRESIDENTS.

1903-04.—Hutton, Captain Frederick Wollaston, F.R.S.
 1905-06.—Hector, Sir James, M.D., K.C.M.G., F.R.S.
 1907-08.—Thomson, George Malcolm, F.L.S., F.R.S.N.Z.
 1909-10.—Hamilton, Augustus.
 1911-12.—Cheeseman, Thomas Frederick, F.L.S., F.Z.S., F.R.S.N.Z.
 1913-14.—Chilton, Charles, M.A., D.Sc., LL.D., F.L.S., C.M.Z.S., F.R.S.N.Z.
 1915 —Petrie, Donald, M.A., Ph.D., F.R.S.N.Z.
 1916-17.—Benham, William Blaxland, M.A., D.Sc., F.R.S., F.Z.S., F.R.S.N.Z.
 1918-19.—Cockayne, Leonard, C.M.G., Ph.D., F.R.S., F.L.S., F.R.S.N.Z.
 1920-21.—Easterfield, Thomas Hill, M.A., Ph.D., F.I.C., F.C.S., F.R.S.N.Z.
 1922-23.—Kirk, Harry Borrer, M.A., F.R.S.N.Z.
 1924-25.—Marshall, Patrick, M.A., F.G.S., F.R.S.N.Z.
 1926-27.—Aston, Bernard Cracroft, F.I.C., F.C.S., F.R.S.N.Z.
 1928 —Thomson, J. Allan, M.A., D.Sc., F.G.S., F.R.S.N.Z. (Mr B. C. Aston reappointed May, 1928, *vice* Dr J. Allan Thomson, deceased).
 1929-30.—Farr, Clinton Coleridge, D.Sc., F.R.S., F.P.S.L., F.R.S.N.Z.
 1931-32.—Segar, Hugh William, M.A.
 1933-34.—Speight, Robert, M.A., M.Sc., F.G.S., F.R.S.N.Z.
 1935-36.—Williams, Rt. Rev. Bishop, M.A., Litt.D. (Cantab & N.Z.), F.R.S.N.Z.

HONORARY MEMBERS.

	Elected
Andrews, E. C., B.A., F.G.S., 32 Benelong Crescent, Bellevue Hill, Sydney	1934
Bragg, Professor Sir William, O.M., K.B.E., F.R.S., Royal Institution, 21 Albemarle Street, London, W.1	1923
Buck, P. (Te Rangi Hiroa), M.D., Ch.B. (N.Z.), F.R.S.N.Z., Bishop Museum, Honolulu	1934
Chapman, F., F.G.S., Commonwealth Palaeontologist, National Museum, Melbourne, Victoria	1932
Compton, Professor A. H., Ph.D., Sc.D., LL.D., University of Chicago, Chicago, U.S.A.	1934
Diels, Professor L., Ph.D., Director Botanic Garden and Museum, Dahlem, Berlin	1907
Einstein, Professor Albert, Princeton University, New Jersey, U.S.A.	1924
Fraser, Sir J. G., D.C.L., Trinity College, Cambridge	1920
Gatenby, J. B., M.A., Ph.D., B.Sc., D.Sc., Professor of Zoology and Com- parative Anatomy, University, Dublin	1934
Haddon, Dr A. C., F.R.S., 3 Cranmer Road, Cambridge	1925
Hall, Sir A. D., K.C.B., M.A., D.Sc., F.R.S., Ministry of Agriculture, London	1920
Hill, Sir A. W., K.C.M.G., Sc.D., D.Sc., F.R.S., Director Royal Botanic Gardens, Kew	1928
Hopkins, Sir Frederick Gowland, O.M., M.A., M.B., D.Sc., University of Cambridge	1937
Jaggard, Dr T. A., Director of Volcanological Observatory, Volcano House, P.O., Hawaii	1927
Jeans, Sir James H., D.Sc., F.R.S., Cleveland Lodge, Dorking, Surrey	1929
Malinowski, Bronislaw, Ph.D. (Cracow), D.Sc. (Lond.), Prof. of Social Anthropology, London School of Economics, London	1936
Marshall, Sir Guy A. K., C.M.G., F.R.S., 16 Cranley Place, London, S.W.7	1933
Mawson, Sir Douglas, B.E., D.Sc., F.R.S., The University, Box 498, Adelaide, South Australia	1920
Mellor, J. W., D.Sc., Sandon House, Regent Street, Stoke-on-Trent, England	1919
Mortensen, Theodor, Ph.D., Director of the Department of Invertebrates of the Zoological Museum, Copenhagen	1927
Rivett, Sir David, K.C.M.G., M.A., B.Sc. (Oxon), D.Sc. (Melb.)	1937
Russell, Sir John, D.Sc., F.R.S., Director of Rothamsted Experiment Station, Harpenden	1928
Seward, Professor A. C., Sc.D., F.R.S., Botany School, Cambridge	1928
Skottsberg, Professor C., D.Sc., Botaniska Trädgården, Göteborg, Sweden	1938
Wilckens, Dr. Otto, Bonn University, Bonn	1936
Woods, Henry, M.A., F.R.S., F.G.S., Sedgwick Museum, Cambridge	1920

FORMER HONORARY MEMBERS.

Elected		Elected	
Agardh, Dr J. G.	1900	Hochstetter, Dr Ferdinand von . .	1870
Agassiz, Professor Louis . . .	1870	Hooker, Sir J. D., F.R.S. . . .	1870
Arber, Dr E. A. Newell . . .	1914	Howes, G. B., F.R.S.	1901
Armstrong, Prof. H. E., F.R.S. .	1927	Huxley, Thomas H., F.R.S. . .	1872
Avebury, Lord, P.C., F.R.S. . .	1900	Klotz, Professor Otto J. . . .	1903
Baird, Professor Spencer F. . .	1877	Langley, S. P.	1896
Balfour, Prof. I. Bayley, F.R.S. .	1914	Lindsay, W. L., M.D.	1871
Bateson, Professor W., F.R.S. . .	1915	Liversidge, Professor A., F.R.S. .	1890
Beddard, Dr F. E., F.R.S. . . .	1906	Lotsy, Dr J. P.	1927
Beneden, Professor J. P. van . .	1888	Lydekker, Richard, F.R.S. . . .	1896
Berggren, Dr S.	1876	Lyell, Sir Charles, F.R.S. . . .	1873
Bowen, Sir George Ferguson, G.C.M.G.	1873	Massart, Professor Jean	1916
Brady, Dr G. S., F.R.S.	1906	McCoy, Professor Sir F.	1888
Bruce, Dr W. S.	1910	McLauchlan, Robert	1874
Carpenter, Dr W. B., F.R.S. . . .	1883	Massee, George	1900
Chree, Dr Charles, F.R.S. . . .	1924	Masson, Sir D. Orme, F.R.S. . .	1928
Clarke, Rev. W. B., F.R.S. . . .	1876	Meyrick, E., F.R.S.	1907
Codrington, Rev. R. H., D.D. . .	1894	Milne, J., F.R.S.	1906
Curie, Madame Marie	1927	Mitten, William, F.R.S.	1895
Darwin, Charles, M.A., F.R.S. . .	1871	The Most Noble the Marquis of Normanby	1880
Darwin, Sir George, F.R.S. . . .	1909	Mueller, Dr Ferdinand von, F.R.S. .	1870
David, Professor T. Edgeworth, F.R.S.	1904	Muller, Professor Max, F.R.S. . .	1878
Davis, J. W.	1891	Newton, Alfred, F.R.S.	1874
Davis, Professor W. Morris . . .	1913	Nordstedt, Professor Otto	1890
Dendy, Dr A., F.R.S.	1907	Owen, Professor Richard, F.R.S. .	1870
Drury, Captain Byron	1870	Pickard-Cambridge, Rev. O. . . .	1873
Ellery, R. L. J., F.R.S.	1883	Richards, Rear-Admiral G. H. . .	1870
Etheridge, Professor R., F.R.S. . .	1876	Riley, Professor C. V.	1890
Ettingshausen, Baron von	1888	Rolleston, Professor G., M.D., F.R.S.	1875
Eve, H. W., M.A.	1901	Ross, Sir Ronald	1929
Filhol, Dr H.	1875	Rutherford, Lord, F.R.S.	1904
Finsch, Professor Otto	1870	Sars, Professor G. O.	1902
Flower, Professor W. H., F.R.S. . .	1870	Schmidt, Professor J.	1930
Garrod, Professor A. H., F.R.S. . .	1878	Sclater, Dr P. L., F.R.S.	1875
Goebel, Professor Dr Carl von . .	1901	Sharp, Dr D.	1877
Goodale, Prof. G. L., M.D., LL.D. .	1891	Sharp, R. B., F.R.S.	1885
Gray, Dr J. E., F.R.S.	1871	Stebbing, Rev. T. R. R., F.R.S. . .	1907
Gray, Professor Asa	1885	Stokes, Vice-Admiral J. L. . . .	1872
Gregory, Professor J. W., F.R.S. .	1920	Tenison-Woods, Rev. J. E.	1878
Grey, Sir George, K.C.B.	1872	Thiselton-Dyer, Sir W. T., F.R.S. .	1894
Gunther, Dr A., F.R.S.	1873	Thomson, Prof. Wyville, F.R.S. . .	1874
Haldane, J. S., M.A., M.D., LL.D., F.R.S.	1928	Thomson, Sir Arthur	1928
Haswell, Prof. W. A., F.R.S. . . .	1914	Thomson, Sir William, F.R.S. . .	1883
Hedley, Charles	1924	Tillyard, R. J., F.R.S.	1935
Hemsley, Dr W. Botting, F.R.S. . .	1913	Wallace, Sir A. R., F.R.S.	1885
		Weld, Frederick A.	1877

FELLOWS OF THE ROYAL SOCIETY OF NEW ZEALAND.

ORIGINAL FELLOWS.

(See *New Zealand Gazette*, 20th November, 1919.)

- †*Aston, Bernard Cracroft, F.I.C., F.O.S.
 *††Benham, William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.
 §*Best, Elsdon.
 §†*Cheeseman, Thomas Frederick, F.L.S., F.Z.S.
 §††*Chilton, Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
 §††*Cockayne, Leonard, C.M.G., Ph.D., F.R.S., F.L.S.
 †*Easterfield, Thomas Hill, M.A., Ph.D., F.I.C., F.O.S.
 †*Farr, Clinton Coleridge, D.Sc., F.P.S.L., F.R.S.
 §Hogben, George, C.M.G., M.A., F.G.S.
 †*Hudson, George Vernon, F.E.S.
 †Kirk, Harry Borrer, M.A.
 ††*Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
 §†*Petrie, Donald, M.A., Ph.D.
 §*Rutherford of Nelson, Lord, O.M., D.Sc., Ph.D., LL.D., F.R.S.
 †Segar, Hugh William, M.A.
 §*Smith, Stephenson, Percy, F.R.G.S.
 †*Speight, Robert, M.A., M.Sc., F.G.S.
 Thomas, Algernon Phillips Withiel, M.A., F.L.S.
 §†*Thomson, Hon. George Malcolm, F.L.S., M.L.C.
 §††Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S.

FELLOWS ELECTED.

	Date
Allan, Harry Howard, D.Sc., M.A., F.L.S.	1928
Andersen, Johannes Carl	1923
Archey, Gilbert, M.A., F.Z.S.	1932
†Bartrum, John Arthur, M.Sc.	1928
*Benson, William Noel, B.A., D.Sc., F.G.S., F.R.G.S.	1926
§Brown, J. Macmillan, M.A., LL.D.	1925
*Buck, P. H. (Te Rangi Hiroa), M.D., Ch.B. (N.Z.)	1925
*Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.	1921
†Cunningham, Gordon Herriot, M.Sc., Ph.D.	1929
Curtis, Kathleen M., M.A. (N.Z.), D.I.C. (Lond.), D.Sc. (Lond.), F.L.S.	1936
Denham, Henry George, M.A., M.Sc., D.Sc., Ph.D.	1933
Donovan, William, M.Sc., F.I.C.	1938
*Evans, William Percival, M.A., Ph.D.	1930
Henderson, John, M.A., D.Sc., B.Sc. (in Engineering)	1929
Hilgendorf, Frederick William, M.A., D.Sc.	1921
†*Holloway, John Ernest, L.Th., D.Sc.	1921
Kidson, Edward, O.B.E., M.A., D.Sc.	1931
Laing, Robert Malcolm, M.A., B.Sc.	1922
§MacLaurin, James Scott, D.Sc., F.C.S.	1926
Macleod, Donald Bannerman, M.A., D.Sc.	1935
Marsden, Ernest, O.B.E., D.Sc., F.R.A.S.	1922
*Marwick, John, M.A., D.Sc.	1935
Miller, David, M.Sc., Ph.D.	1931
§Morgan, Percy Gates, M.A., F.G.S., A.O.S.M.	1922
*Oliver, Walter Reginald Brook, M.Sc., D.Sc., F.L.S., F.Z.S.	1927
Park, James, Hon.M.Inst.M.M.Lond., F.G.S.	1921
§Philpott, Alfred, F.E.S.	1930
Rigg, Theodore, M.A., M.Sc., F.I.C.	1932
*Skinner, Henry Devenish, M.A.	1927
Smith, William Herbert Guthrie	1924
§*Sommerville, Duncan McLaren Young, M.A., D.Sc., F.R.S.E., F.R.A.S.	1922
§Tillyard, Robin John, M.A., D.Sc., F.R.S., F.L.S., F.E.S.	1924
§Turner, E. Phillips, F.R.G.S.	1936
Turner, F. J., D.Sc., F.G.S.	1938
†§Williams, Herbert Williams, Rt. Rev. Bishop, M.A.	1923

* Hector Medallist; † Hutton Medallist; †† Past President; § Deceased.

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